Regional absorptive capacity

The skills dimension

THE ROYAL SOCIETY

Regional absorptive capacity –
The skills dimension

Issued: April 2022 DES7684
ISBN: 978-1-78252-585-1

This report and other project outputs can be viewed at: **royalsociety.org/absorptive-capacity**

Cover image: UK topographic map © FrankRamspott.

Contents

Executive summary

The UK economy is marked by massive inequality between and within regions. Successive governments have implemented policies intended to address this challenge, but stark differences remain. The impact of the pandemic has exacerbated existing fragilities and strengthened the case for reducing regional inequality to deliver tangible economic benefits across the UK.

In its plan for growth, the UK government set out three pillars of investment – infrastructure, skills and innovation – which featured in the more recent *Levelling Up White Paper* as drivers for tackling spatial disparity. Skills contribute to economic growth through increased productivity but also through the role that they play in enabling innovation.

One way that skills enable innovation is by increasing organisations' absorptive capacity – the ability to understand and apply new ideas and approaches within a particular environment, or 'place'. This may be through the development of a new technology that permits the creation of a new or differentiated product, or through the adoption of a new process that improves efficiency. The availability of skilled people is a key factor. A report from the Centre for Research on Learning and Life Chances (LLAKES) found that "high skilled employees such as professional engineers and scientists may contribute disproportionately to potential absorptive capacity (the identification and acquisition of useful external knowledge) but firms' abilities to apply this knowledge (ie, to realise this absorptive capacity) depend on intermediate skilled employees as well as on high-skilled employees"[1].

This report examines the economy and labour force of the UK, its constituent nations and regions and a selection of six local economies. Drawing on job postings data curated by Emsi Burning Glass, the analysis reinforces the importance of higher and intermediate level skills and the differences in skills supply and demand that exist both between and within UK regions. The challenge is not limited to narrowing a North-South skills divide or the gap between London, the South East and East of England and the rest. A coherent, holistic policy response is needed which supports all parts of the education system, in all parts of the country.

Key findings

- Between 2010 and 2020, the largest growth in jobs in the UK took place in the professional, scientific and technical activities sector – a sector with above average gross earnings in 2020.
- During the 2010 – 2020 period, the highest growth in demand was for occupations requiring Level 6 (eg, Bachelor's degree) and Level 4/5 qualifications (eg, Apprenticeship (Higher)). Average median earnings in 2020 for these two groups were £45,600 and £30,630 respectively.
- Clusters emerged from grouping the skills relevant to absorptive capacity that were mentioned in online job postings. The six skills clusters profiled in the report are: mechanical product design, software quality, industrial science, control engineering, aerospace data science and data science. Analysis of these clusters indicates unmet demand in a range of occupations relevant to the concept of absorptive capacity.

1. Mason, Geoff *et al.* 2017. Which skills contribute most to absorptive capacity, innovation, and productivity performance? Evidence from the US and Western Europe. https://www.llakes.ac.uk/wp-content/uploads/2021/03/RP-60.-Mason-et-al-final_0.pdf (accessed 16 March 2022)

- Analysis using location quotients to identify whether an industry sector or occupation is over- or under-represented at a regional or local level suggests a link between economic prosperity and higher than average concentrations of occupations relevant to the concept of absorptive capacity.
- In 2020, London, the South East and North West had the highest numbers of absorptive capacity jobs. However, more granular analysis again shows considerable variation both between and within regions.

Importantly, while skills are an essential element of absorptive capacity, they do not provide a complete solution to regional inequality. To increase skills demand, productivity and innovation across the UK, complementary action is required in other areas including healthcare, housing, environment and transport policy, which are outside the scope of the report.

Recommendations for further analysis

The analysis within this report is conducted at the level of NUTS1 and NUTS3 geographies. It does not consider the fact that people will be working and living across these. Further analysis that takes this into account (eg Travel to Work Areas (TTWA)) would be beneficial, not least as transport infrastructure impacts directly on mobility. Analysis of the increase in remote working due to the pandemic on firms' access to talent and the impact upon regional economies would also be beneficial.

Recommendations

AREA FOR ACTION: RESEARCH SKILLS

RECOMMENDATION 1

Relevant research expertise contributes to the absorptive capacity of organisations and regions. There are longstanding cultural and systemic impediments to movement between academia and industry[2], yet porosity between sectors supports innovation and is an important tool in increasing the effectiveness of research[3]. The links between investment in R&D and local growth are greater when research and local industry align.

- Government, public and private research funders and organisations should consider additional support for initiatives that encourage exchange between sectors at all career stages. Interaction that supports regional strengths should be encouraged.
- Collaborations between higher and further education institutions, industry and the wider local community should be better incentivised more generally to enable the development of skills[4] and support research and innovation which align with local economic strengths.
- Research organisations and individual PhD supervisors across the UK should encourage early career researchers to engage with local industry. There is provision within UKRI-funded PhDs to undertake a placement in industry where this is related to the student's training[5]. Students should make use of this provision.

2. Dowling, Ann *et al.* 2015. The Dowling Review of Business-University Research Collaborations. https://www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research (accessed 16 March 2022)
3. Technopolis Group, 2019. Analysis of intersectoral mobility. https://www.technopolis-group.com/wp-content/uploads/2020/06/SSF_Intersectoral-Mobility_Final-Report-191002.pdf (accessed 16 March 2022)
4. Stuart, Mary and Shutt, Liz, 2021. Catching the wave: harnessing regional research and development to level up. https://www.hepi.ac.uk/wp-content/uploads/2021/10/Catching-the-wave-harnessing-regional-research-and-development-to-level-up.pdf (accessed 16 March 2022)
5. UKRI. 2020. UKRI Training Grant Guidance. https://www.ukri.org/wp-content/uploads/2020/10/UKRI-291020-guidance-to-training-grant-terms-and-conditions.pdf (accessed 16 March 2022)

AREA FOR ACTION: TECHNICAL SKILLS

RECOMMENDATION 2

The UK suffers from a shortage of people in the workforce with intermediate technical skills which contribute to absorptive capacity. Since those with basic and intermediate skills tend to be less mobile, local training provision is required.

- Governments across the UK should protect and support a range of mechanisms to deliver intermediate skills. In England, this includes apprenticeships and BTECs as well as the incoming T Levels. Further education should be promoted as complementary to, rather than in competition with, higher education as part of a coherent holistic approach to skills. This could involve broadening the post-16 curriculum with input from employers to combine academic and technical options[6].

6. Royal Society. 2019. Jobs are changing, so should education. https://royalsociety.org/-/media/policy/Publications/2019/12-02-19-jobs-are-changing-so-should-education.pdf (accessed 16 March 2022)

AREA FOR ACTION: FOUNDATIONAL EDUCATION

RECOMMENDATION 3

Action is needed to address the current shortage of qualified STEM teachers, with low numbers and high attrition rates in certain subjects reducing the UK's capacity for providing high quality STEM education[7]. It is also essential that all young people receive high quality guidance on careers so they can understand how employment is changing across the UK and the skills and training needed to achieve their goals[8].

- Incentives for teachers in early career should be reviewed. A cost-benefit analysis found that investing £4 billion in a subject-specific continuous professional development entitlement of 35 hours training per year for every teacher could stop up to 12,000 individuals leaving the profession and boost future earnings of pupils by £61 billion[9].
- Schools across the UK should be supported to engage with local industry, further and higher education institutions and relevant analysis to provide accessible guidance to their pupils on the characteristics of the local, regional and UK labour market. The landscape is not static and such provision must be frequently updated.
- Opportunities for teachers to gain exposure to industry practice and skills needs should be created and promoted. STEM Learning, for example, has given STEM teachers short industry placements[10].

7. Royal Society. 2021. Letter from Sir Adrian Smith PRS to the Science Minister on the UK's offer to research talent. https://royalsociety.org/-/media/policy/Publications/2021/2021-06-03-prs-letter-to-amanda-solloway.pdf (accessed 16 March 2022)
8. Gatsby. 2014. Good Career Guidance. https://www.gatsby.org.uk/uploads/education/reports/pdf/gatsby-sir-john-holman-good-career-guidance-2014.pdf (accessed 16 March 2022)
9. van den Brande, Jens and Zuccollo, James. 2021. The effects of high-quality professional development on teachers and students: A cost-benefit analysis. https://epi.org.uk/publications-and-research/the-effects-of-high-quality-professional-development-on-teachers-and-students/ (accessed 16 March 2022)
10. Careers Research and Advisory Centre, 2017. Evaluation of STEM Insight programme. https://www.stem.org.uk/system/files/elibrary-resources/2017/11/STEM%20Insight%20evaluation%20Final%20Report.pdf (accessed 16 March 2022)

AREA FOR ACTION: ADULT EDUCATION

RECOMMENDATION 4

Better availability of data makes it easier to track changes in the sectoral composition of the economy and associated demand for labour at the UK, national and regional level.

Agencies such as Skills Development Scotland are already using data to improve planning and alignment. In England, the government is exploring initiatives to better predict future skills needs[11] but not all these needs are predictable[12, 13]. It is important that individuals already in the workplace are considered and mechanisms to support continual upskilling are in place. The Lifetime Skills Guarantee in England[14] is a positive step, enabling certain adults to gain a Level 3 qualification at no personal cost. As part of the Lifetime Skills Guarantee and in response to the *Augar Review*[15], the government launched a consultation on the introduction of the Lifelong Loan Entitlement, which would allow young people and adults to study more flexibly and upskill and retrain[16].

- Governments across the UK should consider further action to ensure that individuals already in the workplace can access training to develop their skills. Support should not be limited to those currently without intermediate and higher-level qualifications. Potential mechanisms include human capital tax credits[17]. Careful policy design is essential[18]. Any new support should be part of an explicit strategy to rebuild adult education that considers current regional training provision and nascent and established economic strengths.

11. Department for Business, Energy & Industrial Strategy. 2021. UK Innovation Strategy https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf (accessed 16 March 2022)
12. Haskel, Johnathan *et al.* 2017. Capitalism Without Capital: The Rise of the Intangible Economy
13. Department for Levelling Up, Housing and Communities. 2022. Levelling Up the United Kingdom https://www.gov.uk/government/publications/levelling-up-the-united-kingdom (accessed 16 March 2022)
14. HM Government. 2021. Hundreds of free qualifications on offer to boost skills and jobs. https://www.gov.uk/government/news/hundreds-of-free-qualifications-on-offer-to-boost-skills-and-jobs (accessed 16 March 2022)
15. Department for Education. 2022. Higher and Further Education Minister Michelle Donelan speech on the Augar Review. https://www.gov.uk/government/speeches/higher-and-further-education-minister-michelle-donelan-speech-on-the-augar-review (accessed 16 March 2022)
16. Department for Education. 2022. Lifelong Loan Entitlement: Government consultation. https://consult.education.gov.uk/lifelong-loan-entitlement/lifelong-loan-entitlement-consultation/supporting_documents/BRANDED%20CP%20618%20Lifelong%20Loan%20Entitlement%20Consultation_v2%20print%20version%201.pdf (accessed 16 March 2022)
17. Costa, Rui *et al.* 2018. Investing in People: The Case for Human Capital Tax Credits. https://cep.lse.ac.uk/pubs/download/is01.pdf (accessed 16 March 2022)
18. Creve, Ivor *et al.* 2013. The blunders of our governments.

Chapter one
Context

Left
© EXTREME-PHOTOGRAPHER.

Context

Introduction

COVID-19 has had a devastating global impact. In the UK, at the time of writing over 185,000 people have died from contracting the virus[19]. The impact on the economy has been severe. The country's GDP declined by 9.8% in 2020, the steepest drop since records began[20]. The measures that the government has taken to support businesses and households have cost around £340 billion across 2020 – 2021 and 2021 – 2022[21]. This has led to the budget deficit reaching record levels in peacetime[22].

In March 2021, the UK government published *Build Back Better: our plan for growth*[23]. The plan focuses on three pillars of investment:

- Infrastructure;
- Skills; and
- Innovation.

In delivering growth, the plan states an intention to "level up the whole of the UK", "support the transition to Net Zero" and "support our vision for Global Britain"[24]. Perhaps unsurprisingly, while the framing differs, there is considerable similarity between the 'three pillars' identified by the Government in 2021 and the 'five foundations of productivity' identified in the 2017 *Industrial Strategy: building a Britain fit for the future* as well as the 'five drivers of productivity' prioritised by the last Labour government.

The 'five foundations of productivity' described in the *Industrial Strategy* are:

- Ideas – the world's most innovative economy;
- People – good jobs and greater earning power for all;
- Infrastructure – a major upgrade to the UK's infrastructure;
- Business environment – the best place to start and grow a business; and
- Places – prosperous communities across the UK[25].

19. Public Health England. 2022. Coronavirus (COVID-19) in the UK. https://coronavirus.data.gov.uk/ (accessed 16 March 2022)
20. Brien, Philip *et al.* 2021. Coronavirus: Economic impact. https://commonslibrary.parliament.uk/research-briefings/cbp-8866/ (accessed 16 March 2022)
21. *Ibid*
22. *Ibid*
23. HM Treasury. 2021. Build back better: Our plan for growth. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/968403/PfG_Final_Web_Accessible_Version.pdf (accessed 16 March 2022)
24. *Ibid*
25. Department for Business, Energy & Industrial Strategy. 2017. Industrial Strategy: building a Britain fit for the future. https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future (accessed 16 March 2022)

The 'five drivers of productivity' are:

- Investment in physical capital, such as machinery, equipment and buildings;
- Innovation – the successful exploitation of new ideas;
- Skills – the quantity and quality of labour and different types available in an economy;
- Enterprise – the seizing of new business opportunities by both start-ups and existing firms; and
- Competition – improved productivity by creating incentives to innovate and ensure that resources are allocated to the most efficient firms[26].

This consistency in content over the past 25 years follows broader academic and policy discussions about the fragmented and unequal nature of the UK economy and its impact on politics, society and wellbeing. Economist Philip McCann has argued that while inequalities exist globally, the situation within the UK is particularly severe[27]:

"The UK is a deeply uneven country on two broad dimensions, namely the geographic dimension and the governance dimension. The effects of modern globalisation, and in particular the links between automation, out-sourcing, off-shoring and the 'hollowing out' of many middle-skills jobs, mean that while globally we have observed a broad international convergence between countries' incomes, within advanced economies we increasingly observe a greater polarisation and divergence of incomes. In other words, falling inequalities internationally are widely associated with increasing intra-national inequalities. However, intra-national inequalities also challenge good governance. Yet, the extent to which these inequalities are also both geographical and regional in nature is almost unique in the case of the UK. In most other advanced economies these changing employment, skills and income distributions are dispersed much more evenly across the country, whereas in the UK they appear to be more heavily biased towards certain regions than in almost any other advanced economy."

26. Abramovsky, Laura *et al.* 2005. Productivity Policy. https://ifs.org.uk/uploads/publications/bns/05ebn6.pdf (accessed 16 March 2022)
27. McCann, Philip. 2016. The UK regional-national economic problem

Work by Henry Overman and others has emphasised the importance of understanding to what extent these regional disparities are a result of differences in the characteristics of people who live in different places – 'sorting' – versus different outcomes for the same types of people living in different places – 'area effects'[28].

Regional inequalities are recognised as a problem across the political spectrum[29]. The recently published *Levelling Up White Paper* addresses this directly. Among the 12 levelling-up missions outlined in the document, there is focus on tackling regional disparities in education and skills. The Government commited to improving literacy and numeracy skills of primary school children, ensuring lifetime access to training, focusing on employer-led training so people can develop skills suitable for local industries and increasing the number of adults successfully completing high-quality skills training[30]. Moreover, in the recent response to the *Augar Review of post-18 education and funding*[31], the Government committed additional investment in further education and skills, with the aim of bridging educational attainment gaps. This includes a lifelong loan entitlement which would provide individuals with "a loan entitlement to the equivalent of four years of post-18 education to use over their lifetime"[32].

Regional disparities also exist within the context of research and innovation[33]. This has led to increased discussion of the role of research and innovation in driving productivity growth and the extent to which public funding for research and innovation should be viewed as an instrument for regional growth and allocated on the basis of 'place' as well as 'excellence'. An earlier report by the Royal Society on research and innovation clusters focused on the availability of place-based funding in the UK[34] and whether the creation of research and innovation clusters – "geographic concentrations of industries related by knowledge, skills, inputs, demand and/or other linkages"[35] – should be a policy goal. The Royal Society report found that research and innovation clusters were 'emergent' and so while it may be misguided for policymakers to try and create clusters, they should seek to ensure a set of conditions or success factors, identified in earlier work by the Brookings Institution, were in place. These success factors are:

28. Gibbons, Steve *et al.* 2011. Unequal Britain: How real are regional disparities. https://cep.lse.ac.uk/pubs/download/cp353.pdf (accessed 16 March 2022)
29. Duffy, Bobby *et al.* 2021. Unequal Britain. https://www.ifs.org.uk/inequality/unequal-britain/ (accessed 16 March 2022)
30. Department for Levelling Up, Housing and Communities. 2022. Levelling Up the United Kingdom https://www.gov.uk/government/publications/levelling-up-the-united-kingdom (accessed 16 March 2022)
31. Augar, Philip *et al.* 2019. Review of Post-18 Education and Funding, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805127/Review_of_post_18_education_and_funding.pdf (accessed 16 March 2022)
32. Department for Education. 2022. Higher and Further Education Minister Michelle Donelan speech on the Augar Review. https://www.gov.uk/government/speeches/higher-and-further-education-minister-michelle-donelan-speech-on-the-augar-review (accessed 16 March 2022)
33. McCann, Philip. 2016. The UK regional-national economic problem
34. The Royal Society. 2020. Research and innovation clusters. https://royalsociety.org/-/media/policy/Publications/2020/2020-07-research-and-innovation-clusters-report.pdf (accessed 16 March 2022)
35. Delgado, Mercedes *et al.* 2014 Defining clusters of related industries, https://www.nber.org/papers/w20375.pdf (accessed 16 March 2022)

- a core competency (ie, an area of absolute or comparative research strength);
- access to private and public funding;
- strong leadership;
- highly qualified researchers;
- business capabilities;
- sophisticated demand;
- infrastructure provision;
- a supportive regulatory environment;
- a skilled workforce (commercial and technical expertise to support the research base);
- amenities; and
- patience on the part of policymakers[36].

These success factors are consistent with the drivers of productivity identified by the government, as well as research on the conditions needed to translate research and drive innovation[37].

A later report by the Royal Society contained a profile of the current research and technical workforce in the UK[38]. This found that additional action is required to ensure that the UK has the workforce in place to effectively deliver an uplift in research and development funding. It contained analysis of the different levels of participation in the research and technical workforce by age and gender.

This report is intended to build on earlier work on research and innovation clusters[39] and the research and technical workforce in the UK[40]. It does not include analysis of protected characteristics of the workforce. Further analysis would be beneficial to understand how best to encourage more equitable participation at different levels of skills, within sectors at different levels of geography.
This report is focused on the role of skills as a dimension of absorptive capacity. The purpose is to present a profile of the current economic and skills landscape across the UK to understand the extent to which the different nations and regions of the United Kingdom have the skills required to effectively absorb any increase in research and innovation funding and contribute toward productivity growth. As noted above, skills have a crucial role in the research enterprise in both creating innovation specifically and increasing productivity more broadly.

36. Bailey, Martin Neil *et al.* 2017 Clusters and Innovation Districts: Lessons from the United States Experience, https://www.brookings.edu/wp-content/uploads/2017/12/es_20171208_bailyclustersandinnovation.pdf (accessed 16 March 2022)
37. D'Angelo, Camilla *et al.* 2018. Evidence synthesis on the conditions needed to translate research and drive innovation. https://royalsociety.org/-/media/policy/Publications/2018/fresh-case/evidence-synthesis-on-the-conditions-needed-to-translate-research-and-drive-innovation.pdf (accessed 16 March 2022)
38. The Royal Society. 2021. The research and technical workforce in the UK. https://royalsociety.org/topics-policy/publications/2021/research-and-technical-workforce-uk/ (accessed 16 March 2022)
39. The Royal Society. 2020. Research and innovation clusters. https://royalsociety.org/-/media/policy/Publications/2020/2020-07-research-and-innovation-clusters-report.pdf (accessed 16 March 2022)
40. The Royal Society. 2021. The research and technical workforce in the UK. https://royalsociety.org/topics-policy/publications/2021/research-and-technical-workforce-uk/ (accessed 16 March 2022)

Current analysis suggests that while the UK has a relatively high level of skills overall, there is a shortage of (intermediate) technical skills[41], and that it is these "gaps in basic and technical skills that hold back productivity of workers and firms in the UK"[42]. Work by Simon Field for the Gatsby Charitable Foundation, focused on England, has identified a 'missing middle' – a lack of higher technical education at qualifications Levels 4 and 5[43]. A survey of businesses by the Centre for Economic Performance and the Confederation of British Industries (CBI) on the business response to COVID-19 identified a "lack of skills" as the most important barrier to process innovation and "policies to address skills shortages" as a priority to support product/service innovation[44]. Analysis by the Industrial Strategy Council in 2019 suggests that the skills mismatch will worsen by 2030. Specifically, the analysis states that "seven million additional workers could be under-skilled for the job requirements", while "0.9 million additional workers could be over-skilled"[45].

The impact of the pandemic is likely to exacerbate existing inequalities in learning and could negatively affect the levels of skills in the future workforce. There has been an 'uneven impact on school children, college students and workers', with those from low-income backgrounds particularly negatively affected[46]. Beyond skills and economic performance, these increased inequalities could be evident in health outcomes and levels of social and civic engagement.

The UK remains a leading science nation despite comparatively low levels of investment in research and innovation[47]. The purpose of this report is not to suggest that too much investment is going to any nation, region or type of education provision, but to understand where skills gaps may exist and what types of policy interventions could help the UK to thrive post-pandemic through inclusive productivity-led growth. In the 2021 Autumn Budget and Spending Review, the Government set out plans to increase investment in Research and Development (R&D) to £20bn by 2024 – 2025, provided a revised commitment to increase R&D spending to £22bn in 2026 – 2027 and increased economy-wide investment to 2.4% of GDP in 2027[48]. It also included a commitment to increased funding for skills.

41. Institute for Manufacturing. 2021. UK Innovation Report: Benchmarking the UK's industrial and innovation performance in a global context. https://www.ciip.group.cam.ac.uk/reports-and-articles/uk-innovation-report/download/UK_Innovation_Report_Feb_2021_9kxQOT3.pdf (accessed 16 March 2022)
42. Oliveira-Cunha, Juliana *et al.* 2021. Business time: How ready are UK firms for the decisive decade. https://economy2030.resolutionfoundation.org/wp-content/uploads/2021/11/Business-time.pdf (accessed 16 March 2022)
43. Field, Simon. 2018. The Missing Middle: Higher Technical Education in England. https://www.gatsby.org.uk/uploads/education/the-missing-middle-higher-technical-education-in-england.pdf (accessed 16 March 2022)
44. Oliveira-Cunha, Juliana *et al.* 2021. The business response to Covid-19 one year on: Findings from the second wave of the CEP-CBI survey on technology adoption. https://cep.lse.ac.uk/pubs/download/cepcovid-19-024.pdf (accessed 16 March 2022)
45. Industrial Strategy Council. 2019. UK Skills Mismatch in 2030. https://industrialstrategycouncil.org/sites/default/files/UK%20Skills%20Mismatch%202030%20-%20Research%20Paper.pdf (accessed 16 March 2022)
46. Eyles, Andrew *et al.* 2021. Unequal learning and labour market losses in the crisis: consequences for social mobility. https://cep.lse.ac.uk/_NEW/PUBLICATIONS/abstract.asp?index=7786 (accessed 16 March 2022)
47. The Royal Society. 2021. Investing in UK research and development. https://royalsociety.org/topics-policy/projects/investing-in-uk-research-development/ (accessed 16 March 2022)
48. HM Treasury. 2021. Autumn Budget and Spending Review 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1029974/Budget_AB2021_Web_Accessible.pdf (accessed 16 March 2022)

Skills

Improvements in innovation-led productivity are needed across the UK to help address regional inequalities and achieve improved long-term economic growth. Success will be dependent on a range of factors, including the absorptive capacity of organisations. A crucial dimension of absorptive capacity at a micro and macro level is a workforce with the necessary skills. Specifically, a mix of higher and intermediate skills to support innovation within organisations, ideally complemented by effective management practices. This is intuitive but the conceptualisation of skills is complex, as stated by Gordon Lafer: "The notion of 'skill' has been one of the most elusive and hardest to define concepts in labour economics"[49]. Definition is required to understand the current profile of the UK workforce.

Types of skills

Various methods exist for identifying and classifying skills. The Programme for the International Assessment of Adult Competencies (PIAAC) is a programme of assessment and analysis of adult skills conducted by the The Organisation for Economic Co-operation and Development (OECD)[50]. It provides a picture of performance in three areas of skills: literacy, numeracy and problem solving in technology-rich environments. Within these three skills, "proficiency is described in terms of a scale of 500 points divided into levels. Each level summarises what a person with a particular score can do. Six proficiency levels are defined for literacy and numeracy (Levels 1 through 5 plus below Level 1) and four for problem solving in technology-rich environments (Levels 1 through 3 plus below Level 1)"[51]. While it is useful to understand performance in these three broad areas, further detail is needed to understand the types of skills held by the workforce of the UK and how these relate to the occupations in which they work.

In addition to broad categories of skills there exist taxonomies of occupations. These include expert derived taxonomies like O*NET[52] in the United States, the European Skills, Competences, Qualifications and Occupations (ESCO) taxonomy[53] and the International Standard Classification of Occupations[54]. In the UK, the Standard Occupational Classification (SOC)[55] is used. The links between occupation types and skills within these taxonomies vary. The SOC provides a categorisation of occupations in the UK at varying levels of granularity. Where available, each entry includes a description of the group, typical entry routes and required qualifications, tasks and related job titles. Further detail is contained in Annex A, which includes an illustrative example. Some organisations have used the content of online job adverts and existing relatively static occupational taxonomies such as the SOC to build skills taxonomies that attempt to link occupations with the skills that they require at a more granular level. This is the approach that has been taken in some of the analysis in this report.

49. Toner, Philip. 2011. Workforce skills and innovation: An overview of major themes in the literature. https://www.oecd.org/innovation/inno/46970941.pdf (accessed 16 March 2022)
50. OECD. 2021. PIAAC. https://www.oecd.org/skills/piaac/ (accessed 16 March 2022)
51. OECD. 2013. Country note: England & Northern Ireland. https://www.oecd.org/skills/piaac/Country%20note%20-%20United%20Kingdom.pdf (accessed 16 March 2022)
52. O*NET. 2021. About O*NET. https://www.onetcenter.org/overview.html (accessed 16 March 2022)
53. European Commission. 2019. What is ESCO. https://ec.europa.eu/esco/portal/howtouse/21da6a9a-02d1-4533-8057-dea0a824a17a (accessed 16 March 2022)
54. International Labour Organization. 2021. Introduction to occupational classifications. https://www.ilo.org/public/english/bureau/stat/isco/intro.htm (accessed 16 March 2022)
55. Office for National Statistics. 2020. SOC 2020 Volume 1: structure and descriptions of unit groups. https://www.ons.gov.uk/methodology/classificationsandstandards/standardoccupationalclassificationsoc/soc2020/soc2020volume1structureanddescriptionsofunitgroups (accessed 16 March 2022)

TABLE 1

UK ENIC band framework

UK framework levels	Comparable UK qualifications
–	Post Doctoral award (eg DD, LLD, LittD, MedScD, SD)
RQF Level 8 / SCQF Level 12 / CQFW Level 8	Doctor of Philosophy degree (PhD)
RQF Level 7 / SCQF Level 11 / CQFW Level 7	Master of Philosophy degree (MPhil) / Master of Research (MRes)/ Master's degree/ Integrated Master's degree (eg, MEng, MChem, MPhys, MPharm, MArch, MSci)/ Primary (or first) qualifications in medicine, (eg, BM BS), dentistry (eg, BDS) and veterinary science (eg, BVSc)/ Postgraduate Certificate / Postgraduate Diploma; Apprenticeship (Degree)
RQF Level 6 / SCQF Level 10 / CQFW Level 6	Bachelor (Honours) degree; Bachelor degree; Apprenticeship (Higher)
RQF Level 5 / SCQF Level 8 / CQFW Level 5	Diploma of Higher Education (DipHE); Apprenticeship (Higher)
RQF Level 4 / SCQF Level 7 / CQFW Level 4	Certificate of Higher Education (CertHE); Apprenticeship (Higher)
RQF Level 3 / SCQF Level 6/7 / CQFW Level 3	Overall standard of GCE Advanced (A) level / Scottish Advanced Higher / T Levels/ BTEC Nationals; Apprenticeship (Advanced)
RQF Level 3 / SCQF Level 6 / CQFW Level 3	GCE Advanced Subsidiary (AS) level / Scottish Higher
RQF Level 2 / SCQF Level 5 / CQFW Level 2	GCSE (grades A*-C / 9-4) / Scottish National 5 (grades A-C); Apprenticeship (Intermediate)
RQF Level 1 / SCQF Level 4 / CQFW Level 1	GCSE (grades D-G / 3-1) / Scottish National 4 / Foundation Welsh Baccalaureate; GCSE (grades D-G / 3-1) / Scottish National 4 / Foundation Welsh Baccalaureate

Skills levels

Educational attainment, while not necessarily indicative of the level of skills that an individual possesses, is a useful proxy. Consequently, national qualification frameworks and measured data on labour force educational attainment provide useful systems for understanding the skills levels of a particular workforce. Within the UK, England, Northern Ireland, Wales and Scotland have different qualifications frameworks. The Credit and Qualifications Framework for Wales (CQFW) was adopted by the Welsh Government in 2002[56]. The Regulated Qualifications Framework (RQF) applies to general and vocational qualifications in England and Northern Ireland. Both the CQFW and the RQF have the same nine levels of qualifications. The Scottish Credit and Qualifications Framework (SCQF) is the national qualifications framework for Scotland and uses a different classification for the levels of qualifications that it contains[57]. Table 1 was created using the UK National Information Centre for the recognition and evaluation of international qualifications and skills (UK ENIC) band framework[58]. The framework was created to allow comparison between qualifications in the UK and overseas. The table below provides an abridged overview of qualification levels. Annex B contains a comprehensive table.

Mobility and skills

The introduction of this report described the levels of economic inequality that exist in the UK. This inequality has led to a characterisation of the UK as containing multiple economies rather than one coherent economy[59]. It was noted that the level of inequality in the UK is nearly unique in the developed world. If this is partially a product of differences in the levels of skills between regions, particularly given the comparatively small size of the UK, then it is valuable to understand how individual mobility differs by skills level. A study of mobility by the Government Office for Science suggests that:

"Internal migration in the UK is dominated by young, highly educated, start-of-career, or early career professionals. People move more in the early years of their careers than later on. After a peak age of internal migration at 19, when students move to university, a second peak is evident at age 22. In many cases this second peak reflects graduates moving for employment or further study, returning to their home address or moving in with a partner"[60].

56. Welsh Government. 2018. Credit & Qualifications Framework for Wales. https://gov.wales/sites/default/files/publications/2019-01/cqfw-brochure.pdf (accessed 16 March 2022)
57. Scottish Credit and Qualifications Framework Partnership. 2021. About the Framework. https://scqf.org.uk/about-the-framework/ (accessed 16 March 2022)
58. ENIC UK. 2021. Band Framework. https://enic.org.uk/What%20Is%20Recognition/Band%20Framework/Default.aspx (accessed 16 March 2022)
59. McCann, Philip. 2016. The UK regional-national economic problem
60. GO Science. 2013. Future of Cities: Graduate Mobility and Productivity. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/510421/gs-16-4-future-of-cities-graduate-mobility.pdf (accessed 16 March 2022)

More recent work by the Institute for Fiscal Studies has also found that graduates are more mobile than non-graduates. Furthermore "graduates of more selective universities are more mobile" and that "in general, places with high average earnings attract graduates through migration"[61]. Graduate mobility was also explored in the *Levelling Up White Paper*, which highlighted how such skill-based sorting can amplify regional skills differences. It also found that the availability of jobs that match the qualifications and preferences of workers is an important determinant of mobility and this can reflect in the link between city size and attracted graduates[62].

As graduates tend to be more mobile and research-intensive universities already exist across the whole of the UK, it appears sensible that any new local provision should prioritise building the intermediate level skills, equivalent to CQFW and RQF Levels 4 and 5 and SCQF Level 7 and 8 of the workforce where these are insufficient, or retraining where the skills of the workforce no longer match the needs of local industry. This is not straightforward. It is likely to require greater general provision to support training for individuals by employers, education institutions (including universities), as well as private providers, coupled with targeted training initiatives where there have been structural changes in the local economy. As part of the levelling up strategy, the government plans to strengthen and improve institutions providing skills training locally to allow people to upskill in their own communities[63].

Additionally, while graduates tend to be more mobile, they are mobile to those places with higher average earnings, so those places with lower average earnings can struggle to attract and/or retain graduates. Consequently, while provision at RQF Level 6/ SCQF Level 10/CQFW Level 6 may not need to be delivered locally, additional activity may be required to incentivise people with these skills levels to remain or relocate to areas where the workforce lacks people with these levels of skills. A recent report by the Bridge Group on graduate retention makes several related recommendations for action by universities, employers and the Office for Students. The report's recommendations of universities include "encouraging a local focus for postgraduate research", which fall outside the scope of this report but include adequate transport infrastructure. For example, where people are travelling to another region to work, investments in transport can be transformative in changing opportunities in the travel-to-work area".

While beyond the scope of this report, future work analysing the impact of the COVID-19 pandemic on mobility could indicate how different levels of skills enable remote working and identify which industrial sectors encourage staff mobility.

61. Britton, Jack *et al.* 2021. London calling? Higher education, geographical mobility and early-career earnings. https://ifs.org.uk/publications/15622 (accessed 16 March 2022)
62. Department for Levelling Up, Housing and Communities. 2022. Levelling Up the United Kingdom https://www.gov.uk/government/publications/levelling-up-the-united-kingdom (accessed 16 March 2022)
63. *Ibid*
64. Bridge Group 2021. Staying local: understanding the value of graduate retention for social equality. https://www.thebridgegroup.org.uk/news/bg-upp-report-2021 (accessed 16 March 2022)

Skills infrastructure

Skills training is delivered in a range of environments. Below is a description of the different types of organisations in the UK that provide skills training:

- **Colleges**
  Institutions at the heart of the technical and vocational education and training (TVET) sector in the UK. They deliver a full range of different skills and often have links to schools to support younger pupils from the age of 14.
- **Employers**
  Many employers provide on- and off-the-job training opportunities, often through apprenticeships. Training is normally directly related to the job role and the needs of the organisation but is also broad enough to ensure that learners have the ability to work in their chosen industry for other firms. Leading employers also provide their established employees with the opportunity to update and enhance their skills. The *Levelling Up White Paper* outlines plans to make employers central to skills provision so workers can develop skills relevant to local industries[65].
- **Independent training providers**
  These organisations deliver a range of skills but usually with a focus on the vocationally specific elements. They support employers in developing apprentices in the workplace and deliver broader employability skills training.
- **Schools**
  Delivering a range of core skills and some vocational courses, particularly for learners aged 14 to 18.
- **Universities**
  Alongside academic and higher-level vocational and technical skills, universities also deliver core skills and have an increasing focus on enterprise and employability. Learners usually start higher education aged around 18[66].

Skills policy

The national administrations of Northern Ireland, Scotland and Wales are responsible for their own education policy. Additionally, within England, "there has been some devolution of skills decision-making on funding to English combined authorities"[67]. English skills policy has been characterised by turbulence. Since the 1980s education has fallen under six different ministerial departments, has had 48 secretaries of state with relevant responsibilities, and 28 major pieces of legislation[68]. A short summary of recent developments in skills policy across the four nations is included in Annex C.

65. Department for Levelling Up, Housing and Communities. 2022. Levelling Up the United Kingdom https://www.gov.uk/government/publications/levelling-up-the-united-kingdom (accessed 16 March 2022)
66. British Council. 2021. The UK Skills System. https://www.britishcouncil.org/sites/default/files/bc_uk_skills_sector-an_introduction-june_2017_0.pdf (accessed 16 March 2022)
67. Ravenhall, Mark. 2020. Will devolution of skills funding benefit adult learners in England. https://epale.ec.europa.eu/en/blog/will-devolution-skills-funding-benefit-adult-learners-england (accessed 16 March 2022)
68. Norris, Emma and Adam, Robert. 2017. All Change: Why Britain is so prone to policy reinvention, and what can be done about it. https://www.instituteforgovernment.org.uk/sites/default/files/publications/IfG_All_change_report_FINAL.pdf (accessed 16 March 2022)

Innovation and skills

Innovation drives economic growth through improvements in efficiency of labour and capital, thereby increasing productivity and the creation of new, differentiated products and services. The OECD's 2018 *Oslo Manual* describes two types of innovation:

- "Product innovation: A product innovation is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market.
- Business process innovation: A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm[69]".

These two types of innovation can take place independently or in concert. For example, the development and distribution of COVID-19 vaccinations involves both product innovation – the creation of a new vaccine, and business process innovation – concurrent sequencing in the clinical trials process[70]. As with the development of the COVID-19 vaccines as well as the polymerase chain reaction (PCR) tests used to assist in the tracking of the pandemic[71], the technological developments that enable product innovation often, but not always, draw on underpinning research, both basic and applied.

In the context of the UK's recovery from COVID-19, the Centre for Economic Performance has stated that: "Innovation and diffusion will be key to addressing several structural challenges facing the UK economy. These include improving the UK's longstanding poor productivity performance, addressing largescale disparities across and within regions, and reorientating the economy to reach net zero emissions of greenhouse gases by 2050[72]."

Talent is an essential input resource required by organisations to innovate. Specifically, as stated by Dr Anna Valero "highly skilled individuals are key for the invention of new technologies, and for establishing and managing high performing businesses. More general workforce education... enables the diffusion of technologies and productivity-enhancing practices through the economy[73]". A skilled workforce across the UK will be crucial to enable the innovation that can facilitate the UK's immediate economic recovery and achieve long-term growth. In terms of 'what skills are required', evidence reviews have been conducted that focus on the links between skills and productivity and between skills and innovation.

69. OECD. 2021. Oslo Manual. https://www.oecd.org/science/oslo-manual-2018-9789264304604-en.htm (accessed 16 March 2022)
70. Ball, Philip. 2020. The lightning-fast quest for COVID vaccines — and what it means for other diseases. https://www.nature.com/articles/d41586-020-03626-1 (accessed 16 March 2022)
71. Wei-Haas, Maya. 2020. Key ingredient in coronavirus tests comes from Yellowstone's lakes. https://www.nationalgeographic.com/science/article/key-ingredient-in-coronavirus-tests-comes-from-yellowstone (accessed 16 March 2022)
72. Martin, Ralf *et al.* 2020. Innovation for a strong and sustainable recovery. https://cep.lse.ac.uk/pubs/download/cepcovid-19-014.pdf (accessed 16 March 2022)
73. Valero, Anna. 2021. Education and economic growth. https://cep.lse.ac.uk/pubs/download/dp1764.pdf (accessed 16 March 2022)

A 2009 exploration of the links between skills and productivity by the Warwick Institute for Employment Research found that productivity gains are dependent upon:

- **"management capability:** constructing an appropriate product market strategy, being able to identify skills needs to support that strategy, sourcing skills, and ensuring they are effectively deployed;
- **innovation:** creating an environment where new ideas – no matter how big or small – can flourish and stand a realistic chance of being acted upon;
- **entrepreneurship:** being able to construct an appropriate business plan to exploit economically valuable ideas and being able to deliver to that plan[74]."

A later evidence review by the Productivity Insights Network found that: "Overall, the UK has a relatively high level of skills, and labour force composition contributed positively to productivity growth both before and after the financial crisis. However, the UK does relatively badly in overall levels of job-related training and low- and middle-level skills, both of which have decreased over time. There are also very significant regional variations in educational outcomes and skills, at all education levels, and in terms of adult skills and training. These disparities are among the most significant for any OECD country[75]".

With regard to the link between innovation and skills, an evidence review of *The Effects of Policies for Training and Skills on Improving Innovation Capabilities in Firms* by Nesta found that:

- "There appears to be a positive association between innovative firms and the level of expenditures on formal and informal training, compared to non-innovative firms; and
- Firms benefit from a significant positive effect by developing their 'knowledge pool', particularly with respect to the organization's legacy of past innovations, and the technical competences of owner-managers in small and medium-sized firms[76]."

A literature review of the link between workforce skills and innovation by the OECD found that: "Both the United Kingdom and the United States have world-class research universities, especially in the basic sciences and strong links with industry. Both countries have an above-average performance in high-skill intensive exports such as software, aerospace, advanced defence equipment and fine chemicals. This has led to 'strong performance in some highly skilled sectors', but their overall trade and industrial structure is 'bifurcated between high and low-skill activities. The above points to the importance of intermediate skills in shaping the capacity for product and process innovation, productivity, quality and, consequently, in determining how and what products and services are produced and the international competitiveness of this output. It is important to note that higher level intermediate workforce skills, whilst important, are but one factor in the innovation system of nations such as Germany and Japan[77]".

74. Gambin, Lynn *et al.* 2009. Exploring the Links Between Skills and Productivity. https://warwick.ac.uk/fac/soc/ier/publications/2009/gambin_et_al_2009_skills.pdf (accessed 16 March 2022)
75. Abreu, Maria. 2018. Skills and Productivity. https://productivityinsightsnetwork.co.uk/app/uploads/2018/07/Evidence-Review_Skills-and-Productivity.pdf (accessed 16 March 2022)
76. Grimshaw, Damian *et al.* 2012. The Effects of Policies for Training and Skills on Improving Innovation Capabilities in Firms. https://www.nesta.org.uk/report/the-effects-of-policies-for-training-and-skills-on-improving-innovation-capabilities-in-firms/ (accessed 16 March 2022)
77. Toner, Philip. 2011. Workforce skills and innovation: An overview of major themes in the literature. https://www.oecd.org/innovation/inno/46970941.pdf (accessed 16 March 2022)

This is consistent with a recent literature review on the link between innovation and the technical workforce by Paul Lewis for the Gatsby Charitable Foundation. Lewis provides several illustrative examples of the role of technical staff, typically those with intermediate skills, in supporting innovation and concludes that the UK's capacity to innovate is being "hampered by a shortage of technicians[78]".

Skills and innovation are both crucial to improving productivity across the UK and creating sustainable economic growth. The capacity of an organisation to innovate within an economy depends on the skills of its workforce. The skills required to innovate are in part dependent on both the industrial context and the form of innovation that is being undertaken. While there are gaps in the evidence, reviews suggest that both higher and intermediate skills are necessary[79]. This importance of this skills mix, alongside complementary good management practices[80], is reiterated when one focuses specifically on the concept of absorptive capacity.

Absorptive capacity

Absorptive capacity is an important aspect of innovation systems. However, a lack of systemic readiness and an emerging skills gap suggest that there could be constraints on the absorptive capacity of the UK innovation system[81]. The term, 'absorptive capacity', was popularised by a 1990 article, *Absorptive Capacity: A New Perspective on Learning and Innovation* by Cohen and Levinthal. Absorptive capacity is defined as, "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends[82]". The article goes on to note that: "An organization's absorptive capacity will depend on the absorptive capacities of its individual members. To this extent, the development of an organization's absorptive capacity will build on prior investment in the development of its constituent, individual absorptive capacities, and, like individuals' absorptive capacities, organizational absorptive capacity will tend to develop cumulatively. A firm's absorptive capacity is not, however, simply the sum of the absorptive capacities of its employees…[83]"

78. Lewis, Paul. 2019. Technicians and Innovation: A Literature Review. https://www.gatsby.org.uk/uploads/education/technicians-and-innovation.pdf (accessed 16 March 2022)
79. Toner, Philip. 2011. Workforce skills and innovation: An overview of major themes in the literature. https://www.oecd.org/innovation/inno/46970941.pdf (accessed 16 March 2022)
80. Feng, Andy. 2020. Skill-Biased Management: Evidence from Manufacturing Firms. https://academic.oup.com/ej/article/130/628/1057/5715461 (accessed 16 March 2022)
81. D'Angelo, Camilla *et al.* 2018. Evidence synthesis on the conditions needed to translate research and drive innovation. https://royalsociety.org/-/media/policy/Publications/2018/fresh-case/evidence-synthesis-on-the-conditions-needed-to-translate-research-and-drive-innovation.pdf (accessed 16 March 2022)
82. Cohen, Wesley M *et al.* 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. https://www.jstor.org/stable/2393553?seq=1 (accessed 16 March 2022)
83. *Ibid.*

Additionally: "Absorptive capacity is more likely to be developed and maintained as a by-product of routine activity when the knowledge domain that the firm wishes to exploit is closely related to its current knowledge base. When, however, a firm wishes to acquire and use knowledge that is unrelated to its ongoing activity, then the firm must dedicate effort exclusively to creating absorptive capacity (ie, absorptive capacity is not a by-product). In this case, absorptive capacity may not even occur to the firm as an investment alternative. Even if it does, due to the intangible nature of absorptive capacity, a firm may be reluctant to sacrifice current output as well as gains from specialization to permit its technical personnel to acquire the requisite breadth of knowledge that would permit absorption of knowledge from new domains[84]."

The absorptive capacity of a firm also depends on other factors, such as the extent to which the organisation's structure facilitates the exchange of ideas by individual members of staff. At a regional level, the innovation capacity of a particular region is in part, but not exclusively, dependent on the ability of individual members of the region's workforce to recognise and assimilate information and apply it within their professional environment. Where this information is assimilated from varies and can include research undertaken by private sector organisations as well as publicly funded research undertaken at universities.

In *Capitalism without Capital*, Jonathan Haskel and Stian Westlake highlight work in the US by Shawn Kantor and Alexander Whalley that found modest spillover links between university spending and local economic conditions, though "the links are larger if the university is research-intensive and the conditions in the local area are more conducive to absorbing that research. Those conditions are that firms in the local area are higher skilled and are technically closer to the university's research (eg, they cite university patents)[85]." Other factors in regional absorptive capacity include the organisational structures and informal networks that exist to facilitate the flow of information. In the UK context this includes organisations like Innovate UK KTN.

Individuals' skills are a crucial determinant of organisations', regions' and countries' absorptive capacity. A 2017 research paper[86] sought to understand, "Which skills contribute most to absorptive capacity, innovation, and productivity performance". As with the literature on the links between skills and innovation more broadly, the report found that, "high skilled employees such as professional engineers and scientists may contribute disproportionately to potential absorptive capacity (the identification and acquisition of useful external knowledge) but firms' abilities to apply this knowledge (ie, realise this absorptive capacity) appear to depend in many ways on intermediate skilled employees as well as on high-skilled employees[87]".

84. *Ibid.*

85. Haskel, Johnathan *et al.* 2017. Capitalism Without Capital: The Rise of the Intangible Economy

86. Mason, Geoff *et al.* 2017. Which skills contribute most to absorptive capacity, innovation, and productivity performance? Evidence from the US and Western Europe. https://www.llakes.ac.uk/wp-content/uploads/2021/03/RP-60.-Mason-et-al-final_0.pdf (accessed 16 March 2022)

87. *Ibid*

Chapter two
Analysis

Left
© SDI Productions.

Analysis

Methodology

The analytical section of this report was produced with a combination of data and analysis provided by external consultants Emsi Burning Glass and Royal Society staff.

Emsi Burning Glass has access to several sources of labour market data, including a core structural dataset that draws from nine government data sources[88], each covering different labour market characteristics (eg, salaries). Around 20 million additional datapoints are added to the dataset annually, providing a robust base from which to analyse existing labour market characteristics and to look at how the market may change in the future.

Additionally, Emsi Burning Glass has a real-time job postings dataset, with over 50 million entries captured since the start of 2016. The underlying data is developed by harvesting from over 20,000 job boards for postings and then applying extensive deduplication processes to arrive at between 700,000 and 900,000 unique postings each month.

These postings are then extensively analysed and tagged to develop a database searchable in terms of:

- **Location**
  Classified down to local authority district level but also named towns and cities.
- **Job roles**
  Classified to the ONS Standard Occupational Classification, but also the more granular Emsi Burning Glass Titles taxonomy, with more than 75,000 titles.
- **Skills**
  Using a taxonomy developed from postings, these are further broken into hard skills – ranging from C++ to pruning – and soft skills, such as creativity or ethics.
- **Company names**
  Identified from the job advert wherever possible, to allow for analysis of recruiting organisations.

The data contained within this report draws on Emsi Burning Glass's core structural dataset as well as data related to skills that appear particularly relevant to firms' absorptive capacity. These skills were identified in consultation with the Royal Society. This was done by a review of skills associated with Standard Occupational Classification (SOC) codes that appeared relevant to the concept of absorptive capacity.

This selection was based on the discussion in the previous section of this report and drawn from previous work by the Royal Society on the research and technical workforce in the UK[89] and work by the Royal Society and the University of Warwick Institute of Employment Research to identify the breadth of occupations that exist within the scientific workforce.

88. The Office for National Statistics (ONS) Annual Business Inquiry, the ONS Annual Population Survey, the ONS Annual Survey of Hours and Earnings, the ONS Business Register and Employment Survey, DEFRA Statistics, the ONS Labour Force Survey, the ONS Subnational Population Projections; ONS Workforce Jobs Series.

89. Royal Society. 2021. The research and technical workforce in the UK. https://royalsociety.org/topics-policy/publications/2021/research-and-technical-workforce-uk/ (accessed 16 March 2022)

This selection is based on the 2010 SOC taxonomy[90] and is not exhaustive. It includes the following SOC codes: 112 Production managers and directors; 211 Natural and social science professionals; 212 Engineering professionals; 213 Information technology and telecommunications professionals; 214 Conservation and environment professionals; 215 Research and development managers; 221 Health professionals; 311 Science and engineering technicians; 312 Architectural technicians; 313 Information technology technicians; 321 Health associate professionals; 355 Conservation and environmental associate professionals; 52 Skilled metal, electrical and electronic trades; 613 Animal technicians. There will be people working in positions that contribute to the absorptive capacity of their organisations that are not included in the occupations above. Conversely, there will be people captured in the classifications above who are employed in tasks that are unrelated to the concept of absorptive capacity. It is also important to note that this selection does not include all those that contribute to 'innovation-led growth'. For example, those working in sales and marketing roles are not included, nor are those in legal occupations or human resources. All can and do contribute to the successful growth of innovative firms. Others may wish to consider a different set of occupations to those that have been selected in this report.

The identification of the six skills clusters in the UK was achieved by capturing approximately 331,000 job postings each containing at least five of the skills that were identified as relevant to absorptive capacity. These skills are not necessarily specific to the occupations captured within the above selection. Skills captured include 'new product development', 'production management' and 'functional design.' These groups were then reviewed and those that seemed to offer the most coherent sets of skills were selected. Finally, job postings data were reviewed against the curated clusters to identify the trends in demand for each cluster.

Details of further education and higher education providers in the UK were drawn variously from the following sources:

- **Higher education providers in the UK**
  The UK Government register of recognised bodies of higher learning institutions that can award degrees[91].
- **Further education providers in England**
  Funding allocation data for the 2020 – 2021 academic year[92].
- **Further education providers in Northern Ireland**
  Northern Ireland Direct list of Further Education (FE) Colleges[93].
- **Further education providers in Scotland**
  Scottish Funding Council list of funded colleges[94].
- **Further education providers in Wales**
  Welsh Government list of Further Education Institutions[95].

90. Office for National Statistics. 2016 SOC 2010. https://www.ons.gov.uk/methodology/classificationsandstandards/standardoccupationalclassificationsoc/soc2010 (accessed 16 March 2022)
91. UK Government. Check if your university or college can award a degree. https://www.gov.uk/check-university-award-degree/recognised-bodies (accessed 16 March 2022)
92. Education & Skills Funding Agency. 2021. 16 to 19 funding allocations: 2020 to 2021 academic year. https://www.gov.uk/government/publications/16-to-19-allocation-data-2020-to-2021-academic-year/16-to-19-funding-allocations-2020-to-2021-academic-year (accessed 16 March 2022)
93. Northern Ireland Direct. Further Education (FE) Colleges. https://www.nidirect.gov.uk/contacts/further-education-fe-colleges (accessed 16 March 2022)
94. Scottish Funding Council. Colleges we fund. http://www.sfc.ac.uk/funding/colleges-we-fund.aspx (accessed 16 March 2022)
95. Welsh Government. Further Education Institutions: contact details. https://gov.wales/further-education-institutions-contact-details (accessed 16 March 2022)

It is important to note that this is not a comprehensive list of all organisations providing training to over 16-year-olds in the UK. For example, it does not include data on employers and independent training providers. Due in part to the complexity of the training landscape across the UK, there does not appear to be a single resource that comprehensively collects and categorises data on all organisations able to provide qualifications in the UK. Further analysis in this area would be beneficial.

Data in this section is presented for Nomenclature of Territorial Units for Statistics (NUTS) 1 regions (East Midlands, East of England, London, North East England, North West England, Northern Ireland, Scotland, South East England, South West England, Wales, West Midlands and Yorkshire and the Humber) and a subset of NUTS3 Regions: Aberdeen City and Aberdeenshire; Barnsley, Doncaster and Rotherham; Belfast; Cambridgeshire County Council (CC); Conwy and Denbighshire; and Peterborough. These six regions were selected to illustrate the divergence that exists across the UK. Three of these regions are the locations of clusters that were featured in the Royal Society's research and innovation clusters report: Barnsley, Doncaster and Rotherham; Belfast; and Cambridgeshire CC[96].

Aberdeen City and Aberdeenshire was selected as a high proportion of its workforce are in occupations related to absorptive capacity, while Conwy and Denbighshire was selected as an illustration of a region with a low proportion of its workforce in occupations related to absorptive capacity (using the selection described earlier in this section). Finally, Peterborough, which borders Cambridgeshire CC was selected to illustrate the variance that can exist within regions and the need for nuance when considering regional differences.

96. Royal Society. 2020. Research and innovation clusters. https://royalsociety.org/-/media/policy/Publications/2020/2020-07-research-and-innovation-clusters-report.pdf (accessed 16 March 2022)

UK

Industrial sector

The 2007 Standard Industrial Classification (SIC) tier one taxonomy is used to classify the different sectors within the economy. Table 2 provides an overview of employment by SIC tier one industrial sector in the UK. Gross average earnings per worker in 2020 are included.

Throughout the 2010 – 2020 period, the largest number of people were employed in the retail sector. Over this 10-year period the sector with the largest percentage increase in employment was in real estate activities (+41.4%), while the largest percentage decrease in employment was in public administration and defence (-11.9%). The largest absolute increase in employment from 2010 to 2020 was in professional, scientific and technical activities (771,090).

TABLE 2

Industrial profile of the UK by sector*

Industry	SIC	Jobs 2010	Jobs 2015	Jobs 2020	Average earnings per worker (£) (2020)**
Accommodation and food service activities	I	1,880,660	2,199,170	2,456,940	16,440
Administrative and support services	N	2,210,820	2,651,710	2,750,560	24,840
Agriculture, forestry and fishing	A	464,040	476,990	528,460	20,540
Arts, entertainment and recreation	R	715,090	735,380	780,690	23,170
Construction	F	1,384,980	1,428,700	1,612,790	36,800
Education	P	2,604,390	2,688,790	2,679,570	27,720
Electricity, gas, steam and air conditioning supply	D	115,350	126,870	135,860	43,380
Financial and insurance activities	K	1,045,790	1,042,570	1,083,450	57,660
Human health and social work activities	Q	3,682,040	3,980,070	4,145,780	25,260
Information and communication	J	1,061,530	1,223,150	1,363,490	46,790
Manufacturing	C	2,434,990	2,468,980	2,512,210	33,570
Mining and quarrying	B	55,840	60,770	54,790	56,430
Other service activities	S	607,050	661,390	675,400	22,980
Professional, scientific and technical activities	M	2,062,350	2,563,580	2,833,440	41,100
Public administration and defence; compulsory social security	O	1,567,660	1,315,280	1,380,890	32,100
Real estate activities	L	450,280	551,620	636,620	30,880
Transportation and storage	H	1,272,200	1,386,850	1,563,430	33,620
Water supply; sewerage, waste management and remediation activities	E	173,950	193,510	213,780	35,410
Wholesale and retail trade and repair of motor vehicles and motorcycles	G	4,649,650	4,793,800	4,785,480	24,640

* Figures rounded to the nearest 10.

** Average gross earnings.

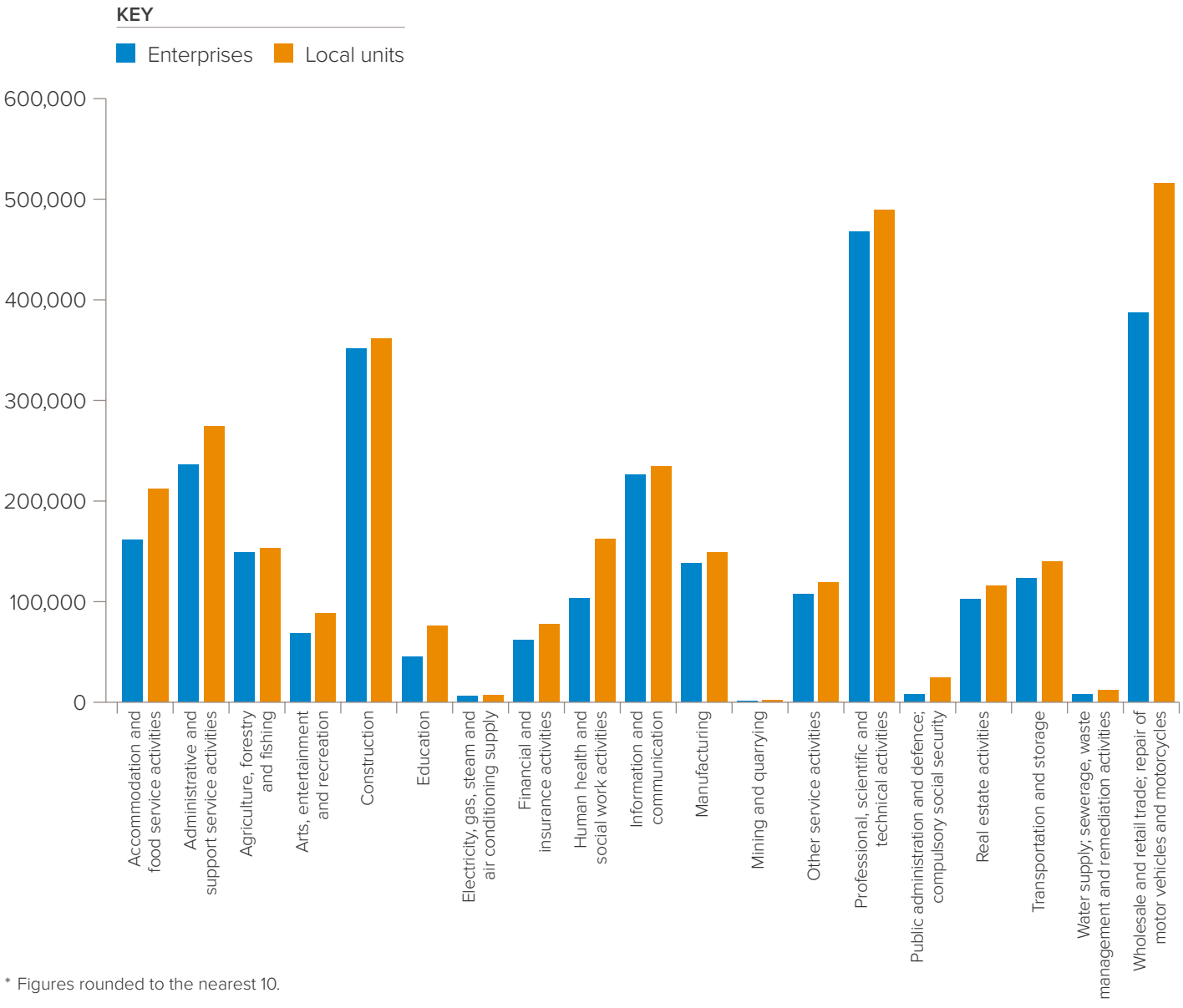
Enterprise and local units

Figure 1 shows the number of enterprises and local units in the UK in 2020 by sector. An enterprise is the 'overall business' whereas a local unit is each individual site or workplace[97]. Figure 1 illustrates which sectors have the highest numbers of local units relative to enterprises.

The sectors with the highest numbers of enterprises and local units in the UK in 2020 were wholesale and retail trade, repair of motor vehicles and motorcycles and professional, scientific, and technical activities.

FIGURE 1

Enterprise profile of the UK by sector in 2020*



* Figures rounded to the nearest 10.

97. Nomis. 2013. UK Business Counts. https://www.nomisweb.co.uk/articles/764.aspx (accessed 16 March 2022)

Labour force qualifications

Table 3 contains details on the qualifications profile of the workforce in the UK. The qualifications represent the typical level of qualification associated with a SOC. These were generated by looking at median qualification levels in labour force survey data, with a few adjustments made based on where some legal requirements may need to be met for someone to hold a job in an occupation. Consequently, the data is indicative. People may have higher or lower levels of qualifications than are associated with their occupation. Annex D contains the list of occupations by qualifications level.

As intimated in the earlier discussion section of this report, most jobs within SOC codes that were selected as relevant to the concept of absorptive capacity require at least a Level 3 qualification.

The average median earnings for jobs requiring Level 7 qualifications (ie, Level 5 NVQ, Masters) are lower than those requiring Level 6 qualifications (ie, Bachelor's degree). The average median earnings for jobs requiring Level 4/5 qualifications are lower than those requiring Level 3 qualifications. It is important to repeat that this is a proxy measure rather than data for people holding those qualifications. Additionally, while there are only five occupations that require Level 7 qualifications and 14 occupations that require Level 4/5 qualifications, there are 97 that require Level 6 qualifications and 108 that require Level 3 qualifications. There is considerable variation between occupations. From 2010 to 2020, the number of jobs at all qualifications levels grew. Growth was largest for jobs requiring Level 6 and Level 4/5 qualifications.

TABLE 3

Qualifications profile of the UK workforce*

Qualification level required	Jobs 2010	Jobs 2016	Jobs 2020	Average median earnings (£) (2020)
Level 7	612,770	662,470	668,770	45,530
Level 6	7,869,290	8,914,630	9,246,980	45,600
Level 4/5	372,980	417,610	430,990	30,630
Level 3	5,720,160	6,176,720	6,442,060	31,200
Level 2	11,886,510	12,749,920	13,202,600	24,240
Level 1	1,914,060	2,063,540	2,138,320	20,190

* Figures rounded to the nearest 10.

Labour demand

Table 4 contains a snapshot of changing labour demand, measured by unique job postings from 2016 – 2020. The table includes occupations selected as relevant to the concept of absorptive capacity[98]. The five occupations that have seen the largest growth and the five that have seen the largest decline have been included.

In addition to those presented in Table 4, other occupations relevant to the research and technical workforce include natural and social sciences professionals (53.9% change in labour demand from 2016 to 2020), laboratory technicians (39.5% change), biological scientists and biochemists (20.3%), building and civil engineering technicians (-16.6%), and mechanical engineers (-21.4%).

Skills infrastructure

Table 5 contains details on the number of higher education and further education providers in the UK. This excludes employers and private providers and so it is not an exhaustive picture of skills provision in the UK.

TABLE 4

Changes in demand for selected occupations (2016 – 2020)

Occupation	SOC	% Change (2016 – 2020)	Unique job postings not elsewhere classified (N.E.C)*				
			2016	2017	2018	2019	2020
Veterinarians	2216	219.5%	3,980	6,610	7,790	9,740	12,710
Pharmacists	2213	164.2%	9,260	13,790	17,750	20,040	24,450
Psychologists	2212	145.0%	11,320	16,270	17,470	23,260	27,720
Pharmaceutical technicians	3217	135.7%	7,400	9,700	14,400	16,780	17,440
Health professionals N.E.C	2219	135.6%	7,270	11,260	10,770	13,960	17,130
Architectural and town planning technicians	3121	-34.7%	20,330	22,410	19,580	18,950	13,280
Tool makers, tool fitters and markers-out	5222	-36.7%	1,320	1,570	1,300	1,310	840
IT project and programme managers	2134	-48.8%	19,550	19,010	14,950	12,810	10,020
TV, video and audio engineers	5244	-61.1%	370	300	210	220	140
Animal care services occupations n.e.c.	6139	-65.9%	9,420	5,250	4,120	3,590	3,210

* Figures rounded to the nearest 10.

TABLE 5

Total higher education and further education providers in the UK

Institution	Quantity
Further education college	211
Higher education institution	171

98. The occupations were selected at a sub-major group (two digit) and minor group (three digit) level. Data is collected at a four-digit level and so constituent occupations of the sub-major and minor groups have been included.

Skills clusters

Cluster analysis is a data analysis technique by which elements are grouped into categories (or clusters) based on similarity. Six UK-wide skills clusters are profiled in this report. Each one is profiled in terms of summary statistics on the number of job postings, the share that are online for a prolonged period (ie, for over 40 days, indicating they are hard to fill and may reflect an unmet demand of skills) and the share with salaries advertised above £50,000. Additionally, for each skills cluster, the top five most frequently encountered job titles and the top 10 most frequently encountered skills in job postings are shown. The top 10 skills in the cluster definition are also shown. These leading cluster skills represent the set of skills which have the most in common across the group of job postings. While they may not be the most frequently encountered skills in the group of job postings, their shared presence across the group gives them a defining role in understanding the skills demands in the cluster.

Skills cluster one – Mechanical product design

This is overwhelmingly a high-skilled cluster, with half of postings found in professional occupations and the rest either managerial or technical roles.

Job titles are heavily overlapping and popular skills align well with those in the underlying cluster – there is a focus on new product development in a mechanical engineering environment, with more emphasis on the softer skills. Although a small area, there is a high share of postings with high time-to-fill, indicating qualified employees are hard to come by.

Employers advertising for this kind of role include GlaxoSmithKline, PerkinElmer and Smith & Nephew.

TABLE 6

Mechanical product design skills cluster overview

Total postings 2016 – 2021*: **1,340**
Share of postings with high time-to-fill: **38%**
Share of postings with a salary greater than £50,000: **22%**

Most popular job titles	Most popular skills (by frequency)	Leading cluster skills
Manufacturing engineers	New product development	New product development
Mechanical engineers	Mechanical engineering	Manufacturing operations
Production engineers	Continuous improvement process	Mechanical engineering
Mechanical design engineers	Lean manufacturing	Good manufacturing practices
	Problem solving	Lean manufacturing
	Communications	Electronics
	Management	Advanced mathematics
	Manufacturing process	Continuous improvement process
	Planning	Medical devices
	Good manufacturing practices	Distributed computing

* Figures rounded to the nearest 10.

Skills cluster two – Software quality

This is the largest of the clusters and was growing fast before the pandemic. 2019 saw 22% growth compared to 2017. A long tail of highly paid roles corresponds to a moderately high number of hard-to-fill postings. Job titles are heavily weighted to quality assurance and testing.

Skills are similar between the underlying cluster and the most popular skills in job postings, with a recent increase in popularity for the technical– more language and software (Java and Selenium enter, Scrum and Agile rise), while new product development and patent applications drop.

Companies advertising include Sky Bet, Deloitte UK, SoftBank and American Express.

TABLE 7

Software quality skills cluster overview

Total postings 2016 – 2021*: **43,660**
Share of postings with high time-to-fill: **32%**
Share of postings with a salary greater than £50,000: **32%**

Most popular job titles	Most popular skills (by frequency)	Leading cluster skills
Quality assurance engineers	Agile methodology	Automation
Test automation engineers	Automation	Software development
Software engineers	Test automation	Agile methodology
Test analysts	Scrum (software development)	Patent applications
Automation testers	Software development	Test automation
	Java (programming language)	Test planning
	Selenium (software)	Scrum (software development)
	Continuous integration	C# (programming language)
	C# (programming language)	Software testing
	Communications	New product development

* Figures rounded to the nearest 10.

Skills cluster three – Industrial science

This is one of the smallest clusters and is overwhelmingly professional and technical in composition – titles are heavily concentrated among scientists and software engineers. Roles are not often highly paid but are among the hardest to fill.

In the initial cluster and among the popular skills, sciences dominate with a special focus on biology and biotechnology. Chemistry, life sciences and pharmaceuticals are also popular.

Companies advertising include Covance, Fujifilm, Lonza, BSI Group and Fisher Scientific.

TABLE 8

Industrial science skills cluster overview

Total postings 2016 – 2021*: **1,750**		
Share of postings with high time-to-fill: **35%**		
Share of postings with a salary greater than £50,000: **16%**		
Most popular job titles	**Most popular skills (by frequency)**	**Leading cluster skills**
Scientists	Biology	Advanced mathematics
Software engineers	Biotechnology	Biology
	Biochemistry	Biotechnology
	Good manufacturing practices	Biochemistry
	Chemistry	Good manufacturing practices
	Life sciences	Physics
	Pharmaceuticals	Life sciences
	Research	Patent applications
	Communications	High-performance liquid chromatography
	Microbiology	Computer science

* Figures rounded to the nearest 10.

Skills cluster four – Control engineering

Relatively stable over time, this is the cluster that has the greatest mix of roles by level – 22% of postings are in the skilled trades category, 23% in technical and 53% in local. Roles are hard to fill compared to similar occupations, and there are relatively fewer highly paid roles than in other clusters. Job titles focus on engineering electrical control systems. Automation is a critical skill, leading the cluster by loading and popularity. In terms of popular skills, the focus is on the technology of PLCs and control systems and instrumentation.

Companies advertising include Amazon, Thames Water, W S Atkins, Glaxo Smith Kline and Corning.

TABLE 9

Control engineering skills cluster overview

Total postings 2016 – 2021*: **4,590**
Share of postings with high time-to-fill: **36%**
Share of postings with a salary greater than £50,000: **8%**

Most popular job titles	Most popular skills (by frequency)	Leading cluster skills
Automation engineers	Automation	Automation
Control systems engineers	Electrical engineering	Electrical engineering
Controls engineers	Programmable logic controllers	Systems engineering
Electrical engineers	Control systems	Control systems
Electrical design engineers	Supervisory control and data acquisition (SCADA)	Instrumentation
	Control engineering	Mechanical engineering
	Instrumentation	Electronics
	Systems engineering	Control engineering
	Communications	Supervisory control and data acquisition (SCADA)
	Commissioning	Data science

* Figures rounded to the nearest 10.

Skills cluster five – Aerospace data science

In this small cluster, roles are relatively hard to fill (34%) and well paid (23% over £50,000). Job titles emphasise software and data science positions.

Skills are heavily geared towards physics and computer science in a manufacturing environment, although popular skills lean towards computing tools and methods.

Companies advertising include Lockheed Martin, Raytheon, Boeing and Leonardo.

TABLE 10

Aerospace data science skills cluster overview

Total postings 2016 – 2021*: **2,590**		
Share of postings with high time-to-fill: **34%**		
Share of postings with a salary greater than £50,000: **23%**		
Most popular job titles	**Most popular skills (by frequency)**	**Leading cluster skills**
Software engineers	Basic math	Computer science
Graduate engineers	Computer science	Basic math
Data scientists	Physics	Physics
Software developers	C++ (programming language)	Distributed computing
	Software development	Patent applications
	Software engineering	Lean manufacturing
	Python (programming language)	Continuous improvement process
	Communications	Mechanical engineering
	C (programming language)	C++ (programming language)
	Algorithms	Manufacturing operations

* Figures rounded to the nearest 10.

Skills cluster six – Data science

This is the second largest of the six clusters and growing fast – 29% growth from 2017 to 2019 before COVID-19. The number of high time-to-fill postings is relatively high (34%) and nearly a quarter of advertised salaries are above £50,000.

The roles concentrate heavily on data science and software engineering, although with a strong scientific bent: physics is the third skill in the cluster definition and is the second most popular. The science background is used as the foundation for a lot of technology work – Python, SQL and C++ are all highly popular.

Companies advertising include Amazon, Boeing, Goldman Sachs, Ocado, W S Atkins and Facebook.

TABLE 11

Data science skills cluster overview

Total postings 2016 – 2021: **34,890**
Share of postings with high time-to-fill: **34%**
Share of postings with a salary greater than £50,000: **23%**

Most popular job titles	**Most popular skills (by frequency)**	**Leading cluster skills**
Data scientists	Basic math	Automation
Software engineers	Physics	Basic math
Systems engineers	Computer science	Physics
Graduate engineers	Communications	Computer science
Software developers	Python (programming language)	Mechanical engineering
	Automation	Electrical engineering
	SQL (programming language)	Planning
	Problem solving	Systems engineering
	Innovation	Test planning
	C++ (programming language)	Advanced mathematics

* Figures rounded to the nearest 10.

National and regional

Industrial sector profile

Table 12 presents the location quotient (LQ) for each 1-digit SIC for the nations and regions of the UK, indicating the national and regional concentration of industrial sectors. Sector titles have been shortened for display. An LQ is a metric used to measure whether a sector or occupation is over or under-represented within an area, relative to the UK as a whole. An LQ of 1.0 indicates that the concentration of an industrial sector in a region is equal to the UK average. An LQ over 1.0 indicates an above average concentration (cells shaded in orange) and an LQ below 1.0 indicates a below average concentration (cells shaded in blue) in those industries. These concentrations show the different sectoral compositions of national and regional economies within the UK. Differences in the concentration of different industrial sectors across nations and regions are not in themselves negative and to some extent these are intuitive. For example, in London there is a high concentration of financial and insurance activities and a low concentration of agricultural, forestry and fishing.

The challenges for economic growth occur when the national or regional economy is dominated by a sector and occupations with low average earnings per worker. The latter tend to be associated with low levels of skills. In these circumstances, low skills equilibria – where there is neither demand for, nor supply of, high-level skills in the workforce – can arise.

London has significant over-representations of sectors that could strongly be associated with absorptive capacity (eg, professional, scientific and technical activities, and information and communication).

The South East, East of England and North East had the largest education LQs at the 1-digit SIC level. When looking specifically at higher education (3-digit SIC 854), this order changes, with Scotland, South East and North East having the highest LQs (1.28, 1.20 and 1.15 respectively).

Sector location quotients are presented at a local level for selected local regions in the UK in Table 14.

TABLE 12

National and regional sector location quotients

An LQ value of 1.0 indicates that the concentration of an industrial sector in a region matches the UK average. An LQ value below 1.0 indicates under-representation of an industrial sector in a region, whereas an LQ value above 1.0 indicates over-representation of an industrial sector in a region.

KEY

Sector	Regions											
	East Midlands	East of England	London	North East	North West	Northern Ireland	Scotland	South East	South West	Wales	West Midlands	Yorkshire and The Humber
Accommodation	0.88	0.91	1.05	1.04	0.91	0.74	1.08	1.01	1.25	1.22	0.96	0.88
Administrative	0.95	1.19	1.23	0.88	0.98	0.67	0.92	0.95	0.81	0.74	1.06	0.97
Agriculture, forestry and fishing	0.88	0.81	0.02	0.55	0.52	9.73	1.26	0.6	1.34	1.97	0.84	0.67
Arts, entertainment and recreation	1.03	1.03	1.09	0.98	1.06	0.70	1.13	0.97	1.00	0.79	0.91	0.93
Construction	0.97	1.24	0.78	0.92	0.94	0.86	1.09	1.09	1.18	0.97	0.93	1.07
Education	1.05	1.09	0.83	1.09	0.94	0.92	0.95	1.14	0.98	1.02	1.03	1.09
Electricity, gas, steam	1.56	0.50	0.52	2.45	1.22	0.45	1.63	0.93	0.97	1.40	0.95	0.76
Financial and insurance activities	0.51	0.75	2.14	0.64	0.79	0.60	0.98	0.78	0.88	0.73	0.73	0.82
Human health and social work	0.91	0.90	0.77	1.26	1.09	1.06	1.22	0.99	1.04	1.18	1.01	1.06
Information and communication	0.58	0.87	2.04	0.70	0.66	0.62	0.81	1.31	0.69	0.47	0.61	0.69
Manufacturing	1.59	0.95	0.29	1.23	1.15	1.19	0.84	0.83	1.08	1.36	1.44	1.41
Mining and quarrying	1.09	0.37	0.27	0.82	0.54	1.21	6.18	0.32	0.94	1.09	0.35	0.42
Other service activities	1.01	0.94	1.13	0.91	0.94	0.87	0.84	1.2	0.88	0.72	1.02	1.03
Professional, scientific	0.86	1.14	1.52	0.70	1.02	0.46	0.83	1.04	0.96	0.61	0.73	0.78
Public administration and defence	0.87	0.74	1.00	1.46	1.04	1.17	1.41	0.72	0.95	1.68	0.84	1.00
Real estate activities	0.76	0.95	1.53	0.88	0.93	0.67	0.84	0.79	1.03	0.74	1.04	0.99
Transportation and storage	1.27	1.02	0.99	0.92	1.15	0.69	0.87	0.94	0.78	0.71	1.25	1.08
Water supply; sewerage	1.07	1.14	0.45	0.82	0.99	1.19	1.13	1.14	1.16	1.53	1.17	0.99
Wholesale and retail trade	1.11	1.05	0.77	0.96	1.09	0.99	0.89	1.11	1.05	1.00	1.08	1.03

Absorptive capacity occupations

Table 13 below presents the number of jobs and combined LQs of the occupations selected as relevant to the concept of absorptive capacity for the nations and regions of the UK.

Among the NUTS1 areas, London, the South East and North West had the highest numbers of absorptive capacity jobs. Out of these areas only the South East had an LQ over 1.0, indicating the other two areas had lower than average proportions of absorptive capacity jobs. The West Midlands, Scotland and East of England had the highest LQs after the South East.

The density of absorptive capacity locations is presented at a local level in Table 15.

TABLE 13

Regional density of absorptive capacity locations (NUTS 1)*

Region	Absorptive capacity occupations	Total occupations (2020)	Location quotient
East Midlands	314,140	2,181,310	1.02
East of England	417,850	2,893,070	1.03
London	710,160	5,450,750	0.92
North East	155,210	1,108,490	0.99
North West	478,090	3,511,510	0.97
Northern Ireland	112,210	967,980	0.82
Scotland	375,690	2,581,160	1.03
South East	680,080	4,342,990	1.11
South West	377,340	2,636,030	1.02
Wales	177,920	1,346,970	0.94
West Midlands	389,720	2,672,540	1.04
Yorkshire and The Humber	346,520	2,500,830	0.98

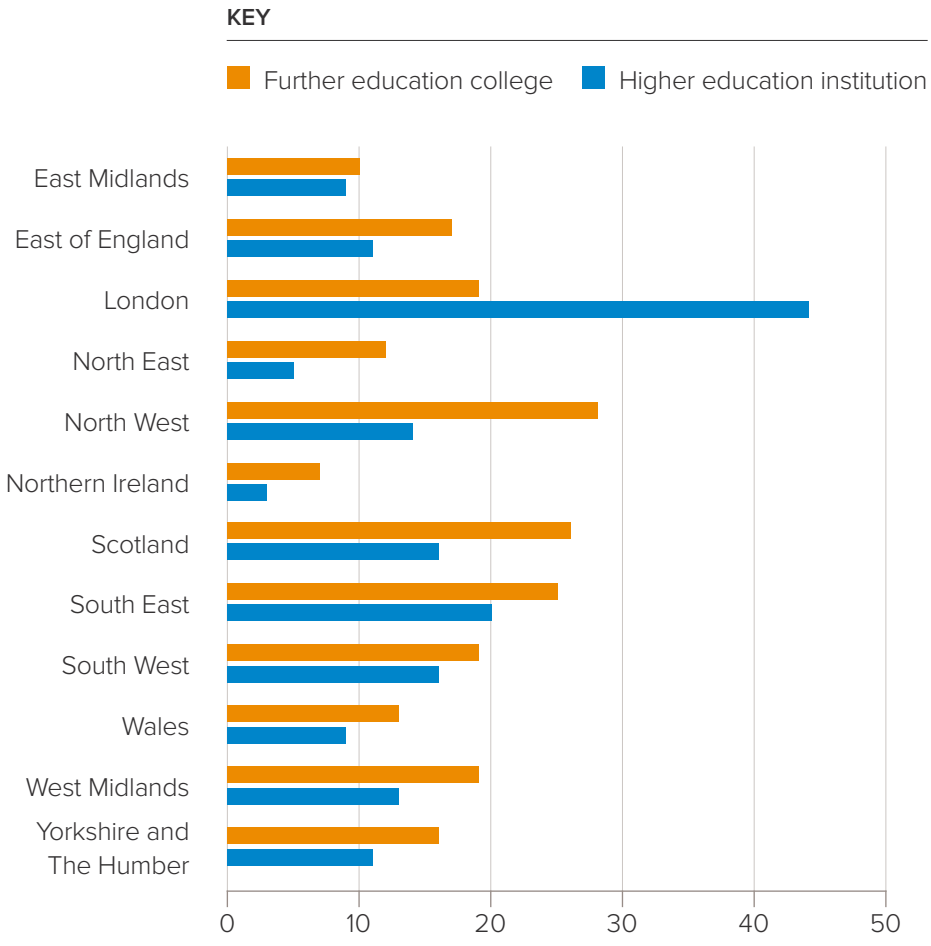
* Figures for occupations rounded to the nearest 10.

Skills infrastructure profile

Figure 2 below shows the distribution of further education colleges and higher education institutions across the UK. Further work would be beneficial to map the respective strengths of these institutions, the amount of provision available in terms of the national or regional population, as well as by level and subject to understand where gaps exist.

FIGURE 2

Distribution of further education colleges and higher education institutions in the UK by region



Local

Industrial sector profile

Table 14 presents the location quotient (LQ) for each 1-digit SIC for six selected local regions in the UK. Sector titles have been shortened for display.

Barnsley, Doncaster and Rotherham (home of Waverley Advanced Manufacturing Park) had a high manufacturing sector LQ (1.54). Cambridgeshire CC had considerably higher professional, scientific and technical activities and education sector LQs than neighbouring Peterborough, where they were both underrepresented, illustrating the variation that can exist within as well as between regions. The sectoral structures of outlying Aberdeen City and Aberdeenshire and Conwy and Denbighshire differ. The first area had large concentrations of the mining and quarrying and professional, scientific and technical activities, while the second was more reliant on accommodation and food services and agriculture, forestry and fishing.

TABLE 14

Local (NUTS3) sector location quotients

KEY

– 1 +

Sector	Local regions: Aberdeen City and Aberdeenshire	Barnsley, Doncaster and Rotherham	Belfast	Cambridgeshire CC	Conwy and Denbighshire	Peterborough
Accommodation	1.00	0.78	0.91	0.85	1.94	0.72
Administrative	0.89	0.90	1.23	0.91	0.81	1.39
Agriculture, forestry and fishing	1.21	0.33	0.06	0.92	2.64	0.35
Arts, entertainment and recreation	0.90	0.80	0.81	0.80	0.77	0.95
Construction	0.97	1.40	0.45	0.91	1.16	0.75
Education	0.77	0.99	0.99	1.48	0.93	0.86
Electricity, gas, steam	0.90	0.68	0.90	0.17	0.69	0.45
Financial and insurance activities	0.22	0.47	1.46	0.34	0.36	1.34
Human health and social work	1.07	1.22	1.15	0.87	1.54	0.95
Information and communication	0.38	0.55	1.52	1.31	0.35	1.25
Manufacturing	0.97	1.54	0.51	1.21	0.67	0.90
Mining and quarrying	51.17	0.35	0.07	0.15	0.84	0.22
Other service activities	0.59	1.05	1.19	1.01	0.65	0.66
Professional, scientific	1.60	0.50	0.95	1.78	0.47	0.64
Public administration and defence	0.92	1.06	2.33	0.66	1.01	0.72
Real estate activities	0.57	0.64	1.14	0.82	0.77	0.85
Transportation and storage	0.81	1.53	0.66	0.68	0.56	1.51
Water supply; sewerage	0.56	0.82	0.95	1.73	1.13	1.18
Wholesale and retail trade	0.79	1.09	0.84	0.76	1.04	1.32

Absorptive capacity occupations

Table 15 presents the number of jobs and combined LQs of the occupations selected as relevant to the research and technical workforce and the concept of absorptive capacity for the six NUTS3 regions in the nations and regions of the UK.

Out of the NUTS3 areas, Cambridgeshire CC had the highest number of absorptive capacity jobs, followed by Aberdeen City and Aberdeenshire and Barnsley, Doncaster and Rotherham. Cambridgeshire CC and Aberdeen City and Aberdeenshire also had the highest LQs, while Barnsley, Doncaster and Rotherham had an LQ of 1.0, indicating the area had the same proportion of jobs in absorptive capacity occupations as the UK on average. Again, there is significant divergence between Cambridgeshire CC and Peterborough.

TABLE 15

Local density of absorptive capacity locations (selected NUTS 3)

Region	Absorptive capacity occupations (2020)	Total occupations (2020)	Location quotient
Aberdeen City and Aberdeenshire	56,930	279,110	1.45
Barnsley, Doncaster and Rotherham	43,930	312,360	1
Belfast	32,190	239,580	0.95
Cambridgeshire CC	70,440	358,140	1.4
Conwy and Denbighshire	9,730	87,630	0.79
Peterborough	15,560	114,210	0.97

* Figures for occupations rounded to the nearest 10.

Skills infrastructure profile

Table 16 below illustrates the distribution of further education colleges and higher education institutions across the six regions. Of the six, Peterborough is the only region without a further education college or higher education institution. However, this is partially a reflection of the limitations of these data as there are private providers based within Peterborough and Anglia Ruskin University is establishing a campus in Peterborough in 2022.

TABLE 16

Distribution of further education colleges and higher education institutions by region

Region	Further education colleges	Higher education institutions
Aberdeen City and Aberdeenshire	1	2
Barnsley, Doncaster and Rotherham	2	0
Belfast	1	3
Cambridgeshire CC	2	2
Conwy and Denbighshire	1	0
Peterborough	0	0

Chapter three
Conclusion

Left
Industrial buildings in Oxfordshire.
© Paul Brown.

Conclusion

The UK is an exceptionally unequal country, and it is likely that the pandemic has exacerbated this. Innovation-led productivity growth is one means by which the regions of the UK can recover from the pandemic. For this growth to occur, several conditions, including adequate public investment, must be in place alongside a skilled workforce. Innovation can only happen given a workforce with the requisite skills. Specifically, "highly skilled individuals are key for the invention of new technologies, and for establishing and managing high performing businesses. More general workforce education... enables the diffusion of technologies and productivity-enhancing practices through the economy[99]". In the wake of the pandemic, a lack of skills has been identified by business in the UK as the primary barrier to innovation. Absorptive capacity is the ability of an organisation to adopt and apply new ideas and practices to their business and create products and process innovations that improve their competitiveness. Previous analysis suggests that a mix of higher and intermediate skills to support innovation within organisations, ideally complemented by effective management skills, improve absorptive capacity. Within the UK a relatively large proportion of the workforce has high level qualifications and skills. However, this is impacted by the 'missing middle' of intermediate level skills, limiting possible growth. Additionally, while graduates tend to be mobile, at least to places of relative prosperity, those with lower levels of skills tend to be less mobile and are not necessarily present in regions where they could make most difference.

The analysis undertaken for this report shows that the largest absolute increase in jobs from 2010 to 2020 was in professional, scientific and technical activities: from 2,062,350 in 2010 to 2,833,440 in 2020. Average gross earnings per worker in this sector in 2020 were £41,100 above the national average. In 2020, the largest number of enterprises in the UK were in the professional, scientific and technical activities sector, while the largest number of local units (individual sites or workplace) were in the retail sector. The largest number of jobs in 2020 required Level 2 qualifications (13,202,600). Average median earnings for these jobs were £24,240. Between 2010 and 2020, growth was largest for jobs requiring Level 6 (eg, Bachelors degree) and Level 4/5 qualifications (eg, Apprenticeship (Higher)). Average median earnings in 2020 for these two groups were £45,600 and £30,630 respectively.

Analysis of demand for skills relevant to the concept of absorptive capacity indicates skills clusters in mechanical product design, software quality, industrial science, control engineering, aerospace data science and data science. All these clusters demand skills typically associated with intermediate and highly skilled workers (qualification Levels 4 and above). The largest of these clusters is software quality, with 43,660 total postings between 2016 and 2021. 32% of postings in this cluster are hard-to-fill and 32% of postings in this skills cluster have a salary greater than £50,000. Popular job titles in this sector include quality assurance engineers and software engineers.

99. Valero, Anna. 2021. Education and economic growth. https://cep.lse.ac.uk/pubs/download/dp1764.pdf (accessed 16 March 2022)

Regional analysis shows considerable variation in the concentration of different industries across the UK. The highest absolute number of people employed in occupations relevant to absorptive capacity were in London. The highest proportion of the workforce employed in occupations relevant to absorptive capacity were in the South East. The lowest number of people employed in occupations relevant to absorptive capacity in both absolute and relative terms were in Northern Ireland. Low skills equilibria occur where there is neither demand for, nor supply of, high level skills. To drive higher economic growth across the UK, support for sectors that require high-level skills is necessary. This requires active engagement between industry, further and higher education institutions, and national and regional government agencies.

Analysis of a selection of local areas showed a relative sector concentration in professional, scientific and technical activities in Aberdeen City and Aberdeenshire and Cambridgeshire CC. These two regions also had the highest proportion of occupations relevant to the concept of absorptive capacity.

Existing literature and the analysis undertaken for this report show the importance of a workforce with both high and intermediate levels of skills for innovation and growth. These skillsets are complementary. As indicated by the skills clusters outlined above, there is growing and apparently unmet demand for occupations that require both traditional academic and technical qualifications. The higher and further education systems play complementary roles and universities can have an important role in supporting local economic growth through the delivery of intermediate as well as higher skills. Prior analysis suggests that research organisations have the greatest impact on local growth where their research activity is technically relevant to local industry.

Policy recommendations are contained in the executive summary of this report. These are intended to encourage the development of skills that align with local economic strengths and increase regional and local absorptive capacity which leads to innovation. The observed geographical disparities in skills and education align with findings of the *Levelling Up White Paper*, emphasising the need for a holistic policy approach covering all parts of the education system, in all parts of the UK.

Appendices

Left
© wsfurlan.

APPENDIX 1:

Acknowledgements

Steering Group members

The members of the Steering Group involved in this report are listed below. Members acted in an individual and not a representative capacity, and contributed to the project on the basis of their own expertise and good judgement.

Chair	
Professor Dame Athene Donald FRS	Emeritus Professor of Experimental Physics and Master of Churchill College, University of Cambridge

Members	
Professor Peter Bruce FRS	Physical Secretary and Vice-President, Royal Society and Wolfson Professor of Materials, University of Oxford
Professor Russell Foster FRS	Professor of Circadian Neuroscience and Head of the Department of Ophthalmology, University of Oxford
Professor Richard Jones FRS	Professor of Materials Physics and Innovation Policy, University of Manchester
Professor Sir John McCanny FRS	Regius Professor Emeritus of Electronics and Computer Engineering, Queen's University Belfast
Professor Sheila Rowan FRS	Professor of Physics and Astronomy and Director of the Institute for Gravitational Research, University of Glasgow
Professor Nick Talbot FRS	Executive Director and Group Leader, The Sainsbury Laboratory
Professor Hywel Thomas FRS	Professor of Civil Engineering and Director of the Geoenvironmental Research Centre, Cardiff University

Royal Society staff	
Bianca Bana	Policy Adviser
Nancy Bird	UKRI Placement
Louisa Brotherson	UKRI Placement
Peter Finegold	Head of Policy, Education
Tom Frostick	Head of Policy, Research and Innovation
Dr Rupert Lewis	Chief Science Policy Officer
Dr Katie Raymer	Policy Adviser (until September 2021)
Joseph Taylor	Senior Policy Adviser (until December 2021)

The Royal Society is grateful to Emsi Burning Glass who were commissioned to undertake the analysis of job postings data contained within the report.

The Royal Society would also like to thank the Steering Group, Daniel Sandford Smith (Gatsby Foundation), Dr Anna Valero (London School of Economics), and Professor Andy Westwood (University of Manchester) for their advice and feedback.

APPENDIX 2:

Skills level and the Standard Occupational Classification (SOC)

TABLE 17

Example structure for an occupation within the SOC[100]

SOC2020 major group	SOC2020 sub-major group	SOC2020 minor group	SOC2020 unit group	SOC2020 group title
2				Professional Occupations
	21			Science, Research, Engineering and Technology Professionals
		211		Natural and Social Science Professionals
			2114	Physical scientists

100. Office for National Statistics. 2020. SOC 2020 Volume 1: structure and descriptions of unit groups. https://www.ons.gov.uk/methodology/classificationsandstandards/standardoccupationalclassificationsoc/soc2020/soc2020volume1structureanddescriptionsofunitgroups (accessed 16 March 2022)

TABLE 18

Example description of an occupation within the SOC[101]

SOC 2020 unit group	2114
SOC 2020 group title	Physical scientists
Group description	Physical scientists study relationships between matter, energy and other physical phenomena, the nature, composition and structure of the Earth and other planetary bodies and forecast weather conditions and electrical, magnetic, seismic and thermal activity.
Typical entry routes and associated qualifications	Entrants usually possess a degree, although entry may also be possible with an appropriate BTEC/SQA award. Further specialist training is provided on the job. Higher degrees and professional qualifications are available, and some employers may require a postgraduate qualification.
Tasks	• Conducts experiments and tests and uses mathematical models and theories to investigate the structure and properties of matter, transformations and propagations of energy, the behaviour of particles and their interaction with various forms of energy • Uses surveys, seismology and other methods to determine the earth's mantle, crust, rock structure and type, and to analyse and predict the occurrence of seismological activity • Observes, records and collates data on atmospheric conditions from weather stations, satellites, and observation vessels to plot and forecast weather conditions • Applies mathematical models and techniques to assist in the solution of scientific problems in industry and commerce and seeks out new applications of mathematical analysis
Related job titles	• Geologist • Geophysicist • Medical physicist • Meteorologist • Oceanographer • Physicist • Seismologist

101. Office for National Statistics. 2020. SOC 2020 Volume 1: structure and descriptions of unit groups. https://www.ons.gov.uk/methodology/classificationsandstandards/standardoccupationalclassificationsoc/soc2020/soc2020volume1structureanddescriptionsofunitgroups (accessed 16 March 2022)

APPENDIX 3:

Qualifications levels

TABLE 19

Overview of UK qualification framework levels and qualifications

UK Framework Levels	Comparable UK Qualifications
–	Post Doctoral award (eg, DD, LLD, LittD, MedScD, SD)
RQF Level 8 / SCQF Level 12 / CQFW Level 8	Doctor of Philosophy degree (PhD); RQF/CQFW Level 8 Diploma / SQA Professional Development Award at SCQF level 12/ Professional Doctorate (eg, EdD, DClinPsy, DBA)
RQF Level 7 / SCQF Level 11 / CQFW Level 7	Master of Philosophy degree (MPhil) / Master of Research (MRes)/ Master's degree/ Integrated Master's degree (eg, MEng, MChem, MPhys, MPharm, MArch, MSci)/ Primary (or first) qualifications in medicine, (eg, BM BS), dentistry (eg, BDS) and veterinary science (eg, BVSc)/ Postgraduate Certificate / Postgraduate Diploma; Level 7 NVQ / SVQ Level 5/ RQF/ CQFW Level 7 Diploma / SQA Professional Development Award at SCQF Level 11; Apprenticeship (Degree)
RQF Level 6 / SCQF Level 10 / CQFW Level 6	Bachelor (Honours) degree; Bachelor degree; Graduate Certificate/ Graduate Diploma/ Level 6 NVQ / SQA Professional Development Awards at SCQF Level 10; RQF/CQFW Level 6 Diploma / SQA Professional Development Award at SCQF Level 10/ Bachelor (Ordinary) degree; Level 6 NVQ / SVQ Level 4 / SQA Professional Development Award at SCQF Level 9; RQF/CQFW Level 6 Diploma / SQA Professional Development Award at SCQF Level 9; Apprenticeship (Higher)
RQF Level 5 / SCQF Level 8 / CQFW Level 5	Diploma of Higher Education (DipHE); Level 5 NVQ / SVQ Level 4 / SQA Professional Development Award at SCQF level 8/ Foundation degree / BTEC Level 5 / SQA Higher National Diploma (HND) (SCQF level 8); Apprenticeship (Higher)
RQF Level 4 / SCQF Level 7 / CQFW Level 4	Certificate of Higher Education (CertHE); Level 4 NVQ / SQA Professional Development Award at SCQF Level 7/ BTEC Level 4 / SQA Higher National Certificate (HNC) (SCQF Level 7); Apprenticeship (Higher)
RQF Level 3 / SCQF Level 6 – 7 / CQFW Level 3	Overall standard of GCE Advanced (A) level / Scottish Advanced Higher / Scottish; Level 3 NVQ / SVQ Level 3 / SQA Professional Development Award at SCQF Levels 6 and 7/ BTEC National Diploma / Extended Diploma Baccalaureate / Advanced Welsh Baccalaureate

TABLE 19 (continued)

UK Framework Levels	Comparable UK Qualifications
RQF Level 3 / SCQF Level 6 / CQFW Level 3	GCE Advanced Subsidiary (AS) level / Scottish Higher; RQF/CQFW Level 3 Awards/Certificates / SQA Professional Development Award at SCQF Level 6 / SQA Awards at SCQF Level 6/ Technical Level / BTEC National Certificate / Extended Certificate / Foundation Diploma / Scottish Higher / SQA National Certificate at SCQF Level 6 / SQA National Progression Award at SCQF Level 6; Apprenticeship (Advanced)
Between RQF Level 2 / SCQF Level 5 / CQFW Level 2 and RQF Level 3 / SCQF Level 6 / CQFW Level 3	Between GCSE and GCE AS level; Between Levels 2 and 3 NVQ / Between SVQ Levels 2 and 3/ Between BTEC First and BTEC National qualifications / SQA National Certificate at SCQF Levels 5 and 6 / SQA National Progression Award at SCQF Levels 5 and 6
RQF Level 2 / SCQF Level 5 / CQFW Level 2	GCSE (grades A*-C / 9-4) / Scottish National 5 (grades A-C) [1] / Intermediate Welsh; Level 2 NVQ / SVQ Level 2/ BTEC Firsts / SQA National Certificate at SCQF Level 5 / SQA National Progression Award at SCQF Level 5 Baccalaureate; Apprenticeship (Intermediate)
RQF Level 1 / SCQF Level 4 / CQFW Level 1	GCSE (grades D-G / 3-1) / Scottish National 4 / Foundation Welsh Baccalaureate; GCSE (grades D-G / 3-1) / Scottish National 4 / Foundation Welsh Baccalaureate; Level 1 NVQ / SVQ Level 1/ BTEC Level 1 Certificate / Diploma / Scottish National 4
RQF Entry Levels 1 – 3 / SCQF Levels 1 – 3 / CQFW Entry Levels 1 – 3	Below GCSE; RQF/CQFW Entry level 3 Certificates / Functional Skills Awards / SQA National 3 Courses / SQA Awards at SCQF level 3/ RQF/ CQFW Entry Level 3 Award/Certificate/Diploma / SQA National Certificate at SCQF level 3 / SQA National Progression Award at SCQF level 3
RQF Entry Levels 1 – 2 / SCQF Levels 1 – 2 / CQFW Entry Levels 1 – 2	RQF/CQFW Entry level 1-2 Certificates / Functional Skills Awards / SQA National 1-2; RQF/CQFW Entry Level 1-3 Award/Certificate/Diploma / SQA National Certificate at SCQF level 1-3 / SQA National Progression Award at SCQF level 1-3; RQF/CQFW Entry Level 1-2 Award/Certificate/Diploma / SQA National Certificate at SCQF level 2 / SQA National Progression Award at SCQF level 2 Courses / SQA Awards at SCQF level 1-2

APPENDIX 4:

Developments in skills policy

England

Within England, the Department for Education is "responsible for children's services and education, including early years, schools, higher and further education policy, apprenticeships and wider skills in England[102]". The Education and Skills Funding Agency (EFSA) is an executive agency sponsored by the Department for Education. EFSA is responsible for the administration of the majority of public funding for further education through the Adult Education Budget[103]. Since 2019 – 2020, control of the Adult Education Budget for their geographies has been transferred to the Greater London Authority and the Mayoral Combined Authorities of Cambridgeshire and Peterborough, Greater Manchester, Greater London, Liverpool City Region, Tees Valley, West Midland, and the West of England.

Skills policy in England has been subject to frequent change. A 2017 report by the Institute for Government noted that since the 1980s there have been 28 major pieces of legislation related to vocational, FE, and skills training; six different ministerial departments with overall responsibility for education; and 48 secretaries of state with relevant responsibilities. No organisation has survived longer than a decade[104]."

Since the publication of the report there have been several significant policy developments in skills policy in England, beyond the aforementioned devolution. This includes the publication of the *Augar Review*[105] in 2019 and the publication of the *Skills for Jobs White Paper* in 2021. The former included recommendations to strengthen technical education, encourage part-time and later in life education, reforming the further education college network, reforming funding for higher education, providing better support for disadvantaged students, and improving the apprenticeship offer[106]. The *Skills for Jobs White Paper* sets out Government's plans to reform further education in England: suggested interventions are designed to increase the engagement of employers in the development and accreditation of skills provision, increase quantity, quality and coherence of higher technical skills, introduce flexible financial support for lifelong learning, better support teaching, and improve governance and accountability of operators within the system[107].

The *Green Jobs Taskforce report*[108] published in 2021 was commissioned as part of *Ten Point Plan for a Green Industrial Revolution*. The report's recommendations include "industry, the education sector, and government should work together to ensure green careers advice and pathways are a continuous offer for all[109]."

102. HM Government. 2021. Department for Education. https://www.gov.uk/government/organisations/department-for-education (accessed 16 March 2022)
103. Foster, David. 2019. Devolution of the Adult Education Budget. https://commonslibrary.parliament.uk/research-briefings/cbp-8596/ (accessed 16 March 2022)
104. Emma Norris and Robert Adam. 2017. All Change: Why Britain is so prone to policy reinvention, and what can be done about it. https://www.instituteforgovernment.org.uk/sites/default/files/publications/IfG_All_change_report_FINAL.pdf (accessed 16 March 2022)
105. Augar, Philip *et al.* 2019. Review of Post-18 Education and Funding, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805127/Review_of_post_18_education_and_funding.pdf (accessed 16 March 2022)
106. *Ibid*
107. Department for Education. 2021. Skills for Jobs: Lifelong Learning for Opportunity and Growth. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/953514/skills-for-jobs-lifelong-learning-for-opportunity-and-growth_print-ready_pdf.pdf (accessed 16 March 2022)
108. HM Government. 2021. Green Jobs Taskforce: Report to Government, Industry and the Skills Sector. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1003570/gjtf-report.pdf (accessed 16 March 2022)
109. *Ibid*

Northern Ireland

The Department for Employment and Learning (DELNI) is responsible for skills policy in Northern Ireland. In 2011, DELNI published *Success through Skills – Transforming Futures: The Skills Strategy for Northern Ireland*. The Strategy set out four strategic goals to be achieved by 2020:

- "Strategic goal 1: Increase the proportion of those people in employment with Level 2 skills and above to 84 – 90% by 2020, from a baseline of 71.2% in 2008.
- Strategic goal 2: Increase the proportion of those people in employment with Level 3 skills and above to 68 – 76% by 2020, from a baseline of 55.6% in 2008.
- Strategic goal 3: Increase the proportion of those people in employment with Level 4/8 skills and above to 44 – 52%, from a baseline of 33.2% in 2008.
- Strategic goal 4: To increase the proportion of those qualifying from Northern Ireland Higher Education Institutions with graduate and post graduate level courses in STEM subjects (with an emphasis on physical and biological sciences, mathematical and computer science, engineering and technology) by 25 – 30% in 2020 from a baseline of 18% in 2008[110]."

In addition to this overarching strategy, a number of further strategies have been implemented focused on specific aspects of the skills system including "Further Education Means Success – Further Education Strategy" in 2016[111]. Work is currently underway to develop a successor strategy to the plan released in 2020. As part of this process the OECD and the Government of Northern Ireland have worked together to identify the following priorities for the next national skills strategy:

- "Reduce skills imbalances: Enhance the provision of career guidance; strengthen the responsiveness and flexibility of the tertiary education and VET systems; reduce economic inactivity to minimise skills shortages; and improve labour mobility to meet skills demand.
- Create a culture of lifelong learning: Start the development of a culture of lifelong learning early in life; increase motivation of adults to learn; and remove barriers to access adult learning opportunities for individuals and employers.
- Transform workplaces to make better use of skills: Strengthen management and leadership capabilities; develop engaging and empowering workplaces; and strengthen support structures for businesses.
- Strengthen the governance of skills policies: Effect sustainable funding arrangements and commitment for an overarching strategy for the skills system; increase co-ordination and information distribution across the whole of government; and improve employer engagement in the governance of skills policies[112]."

110. DELNI. 2011. Success through skills – Transforming futures. https://www.economy-ni.gov.uk/sites/default/files/publications/economy/Success-through-Skills-Transforming-Futures.pdf (accessed 16 March 2022)

111. DELNI. 2016. Further Education Means Success – Further Education Strategy. https://www.economy-ni.gov.uk/further-education-means-success#:~:text='Further%20Education%20Means%20Success%3A%20The,commitments%20to%20ensure%20their%20delivery. (accessed 16 March 2022)

112. OECD. 2020. OECD Skills Strategy Northern Ireland (United Kingdom): Assessment and Recommendations. https://www.oecd.org/skills/centre-for-skills/OECD_Skills_Strategy_Northern_Ireland_Report_Summary.pdf (accessed 16 March 2022)

Scotland

Skills Development Scotland (SDS) is responsible for the development and delivery of skills policy in Scotland. It is an executive non-departmental public body of the Scottish Government.

SDS's *A Human Future: Strategic Plan 2019 – 2022*, sets out the organisation's strategic goals:

- "All people in Scotland have the skills, information and opportunities they need to succeed in the labour market.
- Scotland's businesses drive productivity and inclusive growth.
- Scotland has a dynamic and responsive skills system.
- SDS leads by example and continuously improves to achieve excellence[113]."

The Plan also details a vision for Scotland in 2035, that the Agency will deliver in collaboration with the Scottish Funding Council (SFC), Highlands and Island Enterprise and the South of Scotland (SoSA). The purpose of this vision is to assist with the creation of a dynamic understanding of economic and skills context and use this information to ensure that the Scottish learning and skills system is well placed to meet the needs of learners and the economy. The Agency's Skills Planning Model already takes into account input from employers and insights gathered through partner agencies and big data approaches to understand where skills gaps exist dynamically. This information is used to create local skills strategies, skills investment plans and skills action plans[114].

Within SDS's Strategic Plan for 2019 – 2022, they reference the publication of a *Future Skills Action Plan*. Key actions identified in the latter are included below;

- "Increasing our investment in workforce development to £20m per annum from 2020 – 2021, building on the current £10m Flexible Workforce Development Fund.
- Addressing skills gaps and shortages as a central part of the Scottish Government's response to the UK's departure from the European Union.
- The National Manufacturing Institute Scotland (NMIS) Manufacturing Skills Academy's development of a catalogue of advanced manufacturing modules, which cater to and recognise a range of industry needs across the sector.
- Skills Development Scotland, the Scottish Qualifications Authority and the Scottish Funding Council will develop and promote a clear definition of meta-skills, the timeless, higher-order skills that create adaptive learners, and fully implement the joint 5 stage skills alignment planning model.
- Continuing to support industry-led Developing the Young Workforce Employer Groups.
- Identifying opportunities to enhance access to upskilling and reskilling opportunities through the Scottish National Retraining Partnership in conjunction with the CBI and STUC.
- As part of the £1.3 billion funding made available to City and Growth Deals, building on work to develop and deliver skills investment plans in each region[115]."

113. Skills Development Scotland. 2019. A Human Future: Strategic Plan 2019-2022. https://www.skillsdevelopmentscotland.co.uk/media/45753/a-human-future-strategic-plan-2019-2022.pdf (accessed 16 March 2022)

114. Skills Development Scotland. 2021. Skills Investment Plans. https://www.skillsdevelopmentscotland.co.uk/what-we-do/skills-planning-alignment/skills-investment-plans/ (accessed 16 March 2022)

115. Scottish Government. 2021 Future skills: action plan. https://www.gov.scot/publications/scotlands-future-skills-action-plan/pages/3/ (accessed 16 March 2022)

Wales

Responsibility for skills policy in Wales is shared between the Minister for Economy[116] and the Minister for Education and Welsh Language[117]. With the former responsible for apprenticeship policy and business skills while the latter is responsible for higher and further education.

The Hazelkorn Review was published in 2016. Its purpose was to review "the oversight of post-compulsory education in Wales with special reference to the future role and function of the Higher Education Funding Council for Wales (HEFCW)[118]." The review made the following recommendations:

- "Develop an overarching vision for the post-compulsory education system for Wales based upon stronger links between education policy, providers and provision, and social and economic goals to ensure the needs of Wales are future-proofed as far as is practicable.
- Establish a single new authority – to be called the Tertiary Education Authority (henceforth TEA) – as the single regulatory, oversight and coordinating authority for the post-compulsory sector.
- Place the needs of learners at the centre of the educational system, by establishing clear and flexible learning and career
- Civic engagement should be embedded as a core mission and become an institution-wide commitment for all post-compulsory institutions.
- Create a better balance between supply-led and demand-led education and research provision shifting away from a market-demand driven system to a mix of regulation and competition-based funding.
- Create the appropriate policies, processes and practices to encourage better long-term and joined-up thinking about the educational needs and requirements for Wales, now and into the future[119]."

116. Welsh Government. 2021. Vaughan Gething MS. https://gov.wales/vaughan-gething-ms (accessed 16 March 2022)
117. Welsh Government. 2021. Jeremy Miles MS. https://gov.wales/jeremy-miles-ms (accessed 16 March 2022)
118. Hazelkorn, Ellen. 2016. Towards 2030: A framework for building a world-class post-compulsory education system for Wales. https://gov.wales/sites/default/files/publications/2018-02/towards-2030-a-framework-for-building-a-world-class-post-compulsory-education-system-for-wales.pdf (accessed 16 March 2022)
119. *Ibid*

Since the publication of the Review, the Welsh Government has published the *Public good and a prosperous Wales – Building a reformed PCET system* in 2017 and *The Employability plan for Wales* in 2018. The latter introduced a strategy aimed at, "reducing unemployment, inactivity and rates of those not in education, employment or training[120]." The former included proposals for a Tertiary and Research Commission for Wales (TERCW), to take up the role of the single new authority recommended in the Hazelkorn Review. The Weingarten Review published in April 2018 set out a number of recommendations for the role of TERCW. In July 2020, the Welsh Government published the Tertiary Education and Research (Wales) Bill in draft for consultation[121]. The consultation closed in December 2020. Subject to legislation, the Commission for Tertiary Education and Research (CTER) will be established by 2023 with responsibility for overseeing the post-16 sector in Wales, "which includes further education (FE), higher education (HE), apprenticeships, sixth forms and Welsh Government funded research and innovation in the post-compulsory education and training (PCET) sector[122]".

120. IPPR Scotland. 2019. A 21st Century Skills System for Wales. https://www.ippr.org/files/2019-07/a-21st-century-skills-system-for-wales-july2019.pdf (accessed 16 March 2022)

121. Welsh Government. 2020. Draft Tertiary Education and Research Bill. https://gov.wales/draft-tertiary-education-and-research-bill (accessed 16 March 2022)

122. Welsh Government. 2021. Commission for Tertiary Education and Research (CTER). https://gov.wales/tertiary-education-and-research-commission (accessed 16 March 2022)

APPENDIX 5:

Qualification level requirements by tier four SOC code

The table below contains details of qualifications level by tier four SOC code. Only two occupations are included at Level 0, 'Aircraft pilots and flight engineers' and 'Finance officers' as the relevant qualification for both occupations, Commercial Pilot License and Certified Public Finance Officer, is a certificate that is outside the Regulated Qualifications Framework. In practice, it is likely people in both occupations will hold higher levels of qualifications and so Level 0 has been removed from the analysis. Occupations selected as relevant to the research and technical workforce and the concept of absorptive capacity are in bold.

TABLE 20

Qualification level requirements by tier four SOC code

Qualification level required	SOC code and occupation title
0	3512: Aircraft pilots and flight engineers; 4124: Finance officers
1	9132: Industrial cleaning process occupations; 9134: Packers, bottlers, canners and fillers; 9139: Elementary process plant occupations n.e.c.; 9211: Postal workers, mail sorters, messengers and couriers; 9219: Elementary administration occupations n.e.c.; 9231: Window cleaners; 9232: Street cleaners; 9233: Cleaners and domestics; 9234: Launderers, dry cleaners and pressers; 9235: Refuse and salvage occupations; 9236: Vehicle valeters and cleaners; 9239: Elementary cleaning occupations n.e.c.; 9251: Shelf fillers; 9260: Elementary storage occupations; 9271: Hospital porters; 9275: Leisure and theme park attendants

TABLE 20 (continued)

2	1190: Managers and directors in retail and wholesale; 1224: Publicans and managers of licensed premises; 1226: Travel agency managers and proprietors; 3313: Fire service officers (watch manager and below); 3414: Dancers and choreographers; 4112: National government administrative occupations; 4121: Credit controllers; 4122: Book-keepers, payroll managers and wages clerks; 4123: Bank and post office clerks; 4129: Financial administrative occupations n.e.c.; 4131: Records clerks and assistants; 4132: Pensions and insurance clerks and assistants; 4133: Stock control clerks and assistants; 4134: Transport and distribution clerks and assistants; 4138: Human resources administrative occupations; 4151: Sales administrators; 4159: Other administrative occupations n.e.c.; 4213: School secretaries; 4214: Company secretaries; 4215: Personal assistants and other secretaries 4216: Receptionists; 4217: Typists and related keyboard occupations; 5111: Farmers; 5112: Horticultural trades; 5113: Gardeners and landscape gardeners; 5114: Groundsmen and greenkeepers; 5119: Agricultural and fishing trades n.e.c.; **5212: Moulders, core makers and die casters**; 5316: Glaziers, window fabricators and fitters; 5411: Weavers and knitters; 5412: Upholsterers; 5413: Footwear and leather working trades; 5419: Textiles, garments and related trades n.e.c.; 5423: Print finishing and binding workers; 5431: Butchers; 5432: Bakers and flour confectioners; 5433: Fishmongers and poultry dressers; 5434: Chefs; 5435: Cooks; 5436: Catering and bar managers; 5441: Glass and ceramics makers, decorators and finishers; 5443: Florists; 5449: Other skilled trades n.e.c.; 6121: Nursery nurses and assistants; 6122: Childminders and related occupations; 6123: Playworkers; 6125: Teaching assistants; 6126: Educational support assistants; 6139: Animal care services occupations n.e.c.; 6145: Care workers and home carers; 6147: Care escorts; 6211: Sports and leisure assistants; 6212: Travel agents; 6214: Air travel assistants; 6215: Rail travel assistants; 6231: Housekeepers and related occupations; 6232: Caretakers; 6240: Cleaning and housekeeping managers and supervisors; 7111: Sales and retail assistants; 7112: Retail cashiers and check-out operators; 7113: Telephone salespersons; 7114: Pharmacy and other dispensing assistants; 7121: Collector salespersons and credit agents; 7122: Debt, rent and other cash collectors; 7123: Roundspersons and van salespersons; 7124: Market and street traders and assistants; 7125: Merchandisers and window dressers; 7129: Sales related occupations n.e.c.; 7130: Sales supervisors; 7213: Telephonists; 7214: Communication operators; 7215: Market research interviewers; 7219: Customer service occupations n.e.c.; 8111: Food, drink and tobacco process operatives; 8112: Glass and ceramics process operatives; 8113: Textile process operatives; 8114: Chemical and related process operatives; 8115: Rubber process operatives; 8116: Plastics process operatives; 8117: Metal making and treating process operatives; 8118: Electroplaters; 8119: Process operatives n.e.c.; 8121: Paper and wood machine operatives; 8122: Coal mine operatives; 8123: Quarry workers and related operatives; 8125: Metal working machine operatives; 8126: Water and sewerage plant operatives; 8127: Printing machine assistants; 8129: Plant and machine operatives n.e.c.; 8131: Assemblers (electrical and electronic products); 8132: Assemblers (vehicles and metal goods); 8134: Weighers, graders and sorters; 8135: Tyre, exhaust and windscreen fitters; 8137: Sewing machinists; 8139: Assemblers and routine operatives n.e.c.; 8141: Scaffolders, stagers and riggers; 8142: Road construction operatives; 8143: Rail construction and maintenance operatives; 8149: Construction operatives n.e.c.; 8211: Large goods vehicle drivers; 8212: Van drivers; 8213: Bus and coach drivers; 8214: Taxi and cab drivers and chauffeurs; 8215: Driving instructors; 8221: Crane drivers; 8222: Fork-lift truck drivers; 8223: Agricultural machinery drivers; 8229: Mobile machine drivers and operatives n.e.c.; 8231: Train and tram drivers; 8233: Air transport operatives; 8234: Rail transport operatives; 8239: Other drivers and transport operatives n.e.c.; 9111: Farm workers; 9112: Forestry workers; 9119: Fishing and other elementary agriculture occupations n.e.c.; 9120: Elementary construction occupations; 9241: Security guards and related occupations; 9242: Parking and civil enforcement occupations; 9244: School midday and crossing patrol occupations; 9249: Elementary security occupations n.e.c.; 9259: Elementary sales occupations n.e.c.; 9272: Kitchen and catering assistants; 9273: Waiters and waitresses; 9274: Bar staff; 9279: Other elementary services occupations n.e.c.

TABLE 20 (continued)

3	**1122: Production managers and directors in construction**; 1161: Managers and directors in transport and distribution; 1162: Managers and directors in storage and warehousing; 1172: Senior police officers; 1173: Senior officers in fire, ambulance, prison and related services; 1211: Managers and proprietors in agriculture and horticulture; 1213: Managers and proprietors in forestry, fishing and related services; 1221: Hotel and accommodation managers and proprietors; 1223: Restaurant and catering establishment managers and proprietors; 1225: Leisure and sports managers; 1241: Health care practice managers; 1251: Property, housing and estate managers; 1252: Garage managers and proprietors; 1253: Hairdressing and beauty salon managers and proprietors; 1254: Shopkeepers and proprietors - wholesale and retail; 1255: Waste disposal and environmental services managers; 1259: Managers and proprietors in other services n.e.c.; **3113: Engineering technicians; 3114: Building and civil engineering technicians; 3115: Quality assurance technicians; 3116: Planning, process and production technicians; 3119: Science, engineering and production technicians n.e.c.; 3122: Draughtspersons; 3131: IT operations technicians; 3132: IT user support technicians**; 3213: Paramedics; 3217: Pharmaceutical technicians; 3239: Welfare and housing associate professionals n.e.c.; 3312: Police officers (sergeant and below); 3314: Prison service officers (below principal officer); 3315: Police community support officers; 3319: Protective service associate professionals n.e.c.; 3413: Actors, entertainers and presenters; 3415: Musicians; 3417: Photographers, audio-visual and broadcasting equipment operators; 3441: Sports players; 3442: Sports coaches, instructors and officials; 3443: Fitness instructors; 3511: Air traffic controllers; 3513: Ship and hovercraft officers; 3531: Estimators, valuers and assessors; 3533: Insurance underwriters; 3536: Importers and exporters; 3537: Financial and accounting technicians; 3539: Business and related associate professionals n.e.c.; 3541: Buyers and procurement officers; 3542: Business sales executives; 3544: Estate agents and auctioneers; **3550: Conservation and environmental associate professionals**; 3561: Public services associate professionals; 4113: Local government administrative occupations; 4114: Officers of non-governmental organisations; 4135: Library clerks and assistants; 4161: Office managers; 4162: Office supervisors; 4211: Medical secretaries; 4212: Legal secretaries; **5211: Smiths and forge workers; 5213: Sheet metal workers; 5214: Metal plate workers, and riveters; 5215: Welding trades; 5216: Pipe fitters**; 5221: Metal machining setters and setter-operators; 5222: Tool makers, tool fitters and markers-out; 5223: Metal working production and maintenance fitters; 5224: Precision instrument makers and repairers; 5225: Air-conditioning and refrigeration engineers; 5231: Vehicle technicians, mechanics and electricians; 5232: Vehicle body builders and repairers: 5234: Vehicle paint technicians; 5235: Aircraft maintenance and related trades; 5236: Boat and ship builders and repairers; 5237: Rail and rolling stock builders and repairers; 5241: Electricians and electrical fitters; 5242: Telecommunications engineers; 5244: TV, video and audio engineers; 5249: Electrical and electronic trades n.e.c.; 5250: Skilled metal, electrical and electronic trades supervisors; 5311: Steel erectors; 5312: Bricklayers and masons; 5313: Roofers, roof tilers and slaters; 5314: Plumbers and heating and ventilating engineers; 5315: Carpenters and joiners; 5319: Construction and building trades n.e.c.; 5321: Plasterers; 5322: Floorers and wall tilers; 5323: Painters and decorators; 5330: Construction and building trades supervisors; 5414: Tailors and dressmakers; 5421: Pre-press technicians; 5422: Printers; 5442: Furniture makers and other craft woodworkers; **6131: Veterinary nurses; 6132: Pest control officers**; 6141: Nursing auxiliaries and assistants; 6142: Ambulance staff (excluding paramedics); 6144: Houseparents and residential wardens; 6146: Senior care workers; 6148: Undertakers, mortuary and crematorium assistants; 6219: Leisure and travel service occupations n.e.c.; 6221: Hairdressers and barbers; 6222: Beauticians and related occupations; 7115: Vehicle and parts salespersons and advisers; 7211: Call and contact centre occupations; 7220: Customer service managers and supervisors; 8124: Energy plant operatives; 8133: Routine inspectors and testers; 8232: Marine and waterways transport operatives.

TABLE 20 (continued)

4/5	1242: Residential, day and domiciliary care managers and proprietors; 2435: Chartered architectural technologists; 2443: Probation officers; **3111: Laboratory technicians; 3112: Electrical and electronics technicians; 3121: Architectural and town planning technicians; 3216: Dispensing opticians; 3218: Medical and dental technicians; 3219: Health associate professionals n.e.c.**; 3234: Housing officers; 3235: Counsellors; 3411: Artists; 3564: Careers advisers and vocational guidance specialists; 6143: Dental nurses
6	1115: Chief executives and senior officials; 1116: Elected officers and representatives; **1121: Production managers and directors in manufacturing; 1123: Production managers and directors in mining and energy**; 1131: Financial managers and directors; 1132: Marketing and sales directors; 1133: Purchasing managers and directors; 1134: Advertising and public relations directors; 1135: Human resource managers and directors; 1136: Information technology and telecommunications directors; 1139: Functional managers and directors n.e.c.; 1150: Financial institution managers and directors; 1181: Health services and public health managers and directors; 1184: Social services managers and directors; **2111: Chemical scientists; 2112: Biological scientists and biochemists; 2113: Physical scientists; 2114: Social and humanities scientists; 2119: Natural and social science professionals n.e.c.; 2121: Civil engineers; 2122: Mechanical engineers; 2123: Electrical engineers; 2124: Electronics engineers; 2126: Design and development engineers; 2127: Production and process engineers; 2129: Engineering professionals n.e.c.; 2133: IT specialist managers; 2134: IT project and programme managers; 2135: IT business analysts, architects and systems designers; 2136: Programmers and software development professionals; 2137: Web design and development professionals; 2139: Information technology and telecommunications professionals n.e.c.; 2141: Conservation professionals; 2142: Environment professionals; 2150: Research and development managers; 2211: Medical practitioners; 2212: Psychologists; 2213: Pharmacists; 2214: Ophthalmic opticians; 2215: Dental practitioners; 2216: Veterinarians; 2217: Medical radiographers; 2218: Podiatrists; 2219: Health professionals n.e.c.**; 2221: Physiotherapists; 2222: Occupational therapists; 2223: Speech and language therapists; 2229: Therapy professionals n.e.c.; 2231: Nurses; 2232: Midwives; 2315: Primary and nursery education teaching professionals; 2316: Special needs education teaching professionals; 2317: Senior professionals of educational establishments; 2318: Education advisers and school inspectors; 2319: Teaching and other educational professionals n.e.c.; 2412: Barristers and judges; 2413: Solicitors; 2419: Legal professionals n.e.c.; 2421: Chartered and certified accountants; 2423: Management consultants and business analysts; 2424: Business and financial project management professionals; 2425: Actuaries, economists and statisticians; 2426: Business and related research professionals; 2429: Business, research and administrative professionals n.e.c.; 2432: Town planning officers; 2433: Quantity surveyors; 2434: Chartered surveyors; 2436: Construction project managers and related professionals; 2442: Social workers; 2444: Clergy; 2449: Welfare professionals n.e.c.; 2451: Librarians; 2461: Quality control and planning engineers; 2462: Quality assurance and regulatory professionals; 2463: Environmental health professionals; 2471: Journalists, newspaper and periodical editors; 2472: Public relations professionals; 2473: Advertising accounts managers and creative directors; 3231: Youth and community workers; 3233: Child and early years officers; 3412: Authors, writers and translators; 3416: Arts officers, producers and directors; 3421: Graphic designers; 3422: Product, clothing and related designers: 3520: Legal associate professionals; 3532: Brokers: 3534: Finance and investment analysts and advisers: 3535: Taxation experts: 3538: Financial accounts managers; 3543: Marketing associate professionals; 3545: Sales accounts and business development managers; 3546: Conference and exhibition managers and organisers; 3562: Human resources and industrial relations officers; 3563: Vocational and industrial trainers and instructors; 3565: Inspectors of standards and regulations; 3567: Health and safety officers; 5245: IT engineers.
7	2311: Higher education teaching professionals; 2312: Further education teaching professionals; 2314: Secondary education teaching professionals; 2431: Architects; 2452: Archivists and curators

The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Society's strategic priorities emphasise its commitment to the highest quality science, to curiosity-driven research, and to the development and use of science for the benefit of society. These priorities are:

- Promoting excellence in science
- Supporting international collaboration
- Demonstrating the importance of science to everyone

For further information
The Royal Society
6 – 9 Carlton House Terrace
London SW1Y 5AG

T +44 20 7451 2500
E science.policy@royalsociety.org
W royalsociety.org

Registered Charity No 207043

ISBN: 978-1-78252-585-1
Issued: April 2022 DES7684